Bank Capital Regulation in the Euro Area and the Sovereign-Bank Nexus*

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We examine how banks in the euro area adjust their exposure to domestic government debt in response to changes in macroprudential capital regulation. In particular, we analyze the effects on the banks' interconnectedness with their sovereign, referred to as the sovereign-bank nexus, which is considered particularly important for financial stability. To this end, we estimate panel vector autoregressive models for euro-area country groups using a measure of macroprudential policy constructed from the Macroprudential Policy Evaluation Database. Our main findings show that banks in peripheral countries increase their holdings of domestic government bonds in response to a restrictive capital-based macroprudential policy shock, suggesting a strengthening of the sovereign-bank nexus. In contrast, in core countries, the reaction is the opposite. We find that differences in capital positions across country groups can explain our results, which are robust to changes in the econometric setup and the macroprudential indicator used.

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1. Introduction

Macroprudential policy has substantially gained in importance in advanced economies over the past two decades. In particular, the Global Financial Crisis of 2007–08 highlighted the need for a holistic macroprudential approach to financial regulation, aimed at increasing the shock absorption capacity of the financial system and mitigating the buildup of systemic risk (International Monetary Fund 2018). An important class of widely used macroprudential policy instruments are the so-called capital-based measures. They are mostly imposed on banks and comprise the regulation of capital and leverage ratios, loan loss provisioning, as well as the regulatory risk weights assigned to different asset classes. Although experience with capital-based macroprudential measures is limited and an academic consensus about their transmission and effectiveness has not yet been reached, several theoretical and empirical studies suggest that these tools do indeed contribute to achieving financial stability objectives.[1]

However, there are concerns that macroprudential capital regulation has the unintended side effect of encouraging banks to increase their exposure to domestic sovereign debt, which reinforces the interconnectedness between them and their sovereigns, referred to as the *sovereign-bank nexus* (Altavilla, Pagano, and Simonelli 2017). This could undermine financial stability (International Monetary Fund 2014, 2018; Basel Committee on Banking Supervision 2017). In particular, the regulatory framework assigns sovereign bonds a favorable treatment reflected by a risk weight of zero.[2] Thus, banks are allowed to increase their government bond portfolios without raising their tier 1 capital, which is an example of *regulatory arbitrage* (Acharya and Steffen 2015).[3]

[1]See Claessens (2015), Cerutti, Claessens, and Laeven (2017), and Galati and Moessner (2018) for a literature survey.

[2]See Basel Committee on Banking Supervision (2017) and European Systemic Risk Board (2019b) for a detailed description of the legal framework.

[3]The euro area represents a special case, as the favorable regulatory treatment of sovereign debt applies symmetrically to the government bonds issued by any member state. Despite this symmetry, however, the government bond portfolios of euro-area banks exhibit substantial home bias.

In this study, we examine how changes in macroprudential capital regulation in the euro area affect banks' holdings of domestic government debt, thereby strengthening or weakening the sovereign-bank nexus. The nexus is widely viewed as one of the most important amplifiers of the European debt crisis in 2010–12, as it gave rise to *doom loops* of mutually reinforcing deteriorations in the sovereign's creditworthiness and solidity of the domestic banking sector (Acharya, Dreschler, and Schnabl 2014; Brunnermeier et al. 2016; Dell'Ariccia et al. 2018; Farhi and Tirole 2018). Given the enduring substantial exposure of euro-area banks to domestic government securities, the nexus is still a challenge to financial stability in the European Monetary Union (EMU) and beyond, which has been reinforced recently by the COVID-19-related surge in public debt (ESRB 2019b; IMF 2019; European Central Bank 2020).

Against this background, we estimate panel vector autoregressive (VAR) models for euro-area member countries to examine the response of banks' domestic sovereign bond holdings to shocks reflecting a tightening in the unsystematic component of capital-based macroprudential policy. The analysis covers the period from 2005:Q1 to 2018:Q4. We construct an indicator to measure changes in macroprudential capital regulation based on the Macroprudential Policy Evaluation Database (MaPPED) developed by Budnik and Kleibl (2018) for member countries of the European Union (EU), which contains detailed information on the regulatory policy measures implemented.

We divide the euro-area countries into two groups, core countries and peripheral countries, to take into account the heterogeneities in economic development observed after the Global Financial Crisis. Our main findings suggest that banks' exposure to domestic sovereign debt responds significantly to changes in the unsystematic component of capital-based macroprudential policy. However, there is a noticeable dichotomy between the two groups of countries. In peripheral countries, banks react to a restrictive capital-based macroprudential policy shock by increasing the balance sheet share of domestic government bonds. In contrast, in core countries, the reaction is the opposite. Therefore, unsystematic shifts in capital-based regulation tend to strengthen the sovereign-bank nexus in the periphery, but weaken it in the core. We discuss the theoretical rationales for our results, relying on the *capital buffer theory.*

In addition, we estimate state-dependent impulse responses for the two country groups, which shows that differences in capital positions can explain our findings. In a battery of robustness checks, we find that the results are robust to explicitly controlling for monetary policy, changes in the econometric setup, and alternative macroprudential policy indicators.

Our analysis does not evaluate the overall effectiveness of macroprudential capital regulation. In fact, we also document that the latter successfully contributes to increasing banks' loss-absorption capacity for any given shock size. However, our main findings show that, in parts of the EMU, shifts in the unsystematic part of capital-based policy might increase banks' exposure to sovereign debt, which promotes a risk to financial stability that might materialize in the future.

The main contributions of our analysis are twofold. First, to the best of our knowledge, we are the first to explore the effects of macroprudential policy shocks on the sovereign-bank nexus from an explicit macroeconomic perspective. This allows us to capture important *aggregate level* interlinkages between banks' behavior and the rest of the economy. By contrast, as we explain below, the closely related contributions, also dealing with the relationship between macroprudential regulation and the nexus, are purely microeconometric in nature, and in some cases derive their conclusions from a single regulatory event (Acharya, Engle, and Pierret 2014; Acharya and Steffen 2015; Bonner 2016; Gropp et al. 2019). These studies have the advantage of exploiting the rich information revealed by bank-level panels but abstract from investigating potential dynamic macroeconomic feedback effects. Our time-series approach allows us to capture general-equilibrium effects and thus to address the "missing intercept problem" (Buera, Kaboski, and Townsend 2023; Wolf 2023). Furthermore, we explore the average effects of various macroprudential measures over the period 2005–18, instead of looking at a single event.

The remainder of this study is organized as follows. Section 2 provides an overview of the related literature. Section 3 discusses our benchmark panel VAR model, the data, and the strategy to identify the unsystematic component of capital-based macroprudential policy. Section 4 describes the construction of our macroprudential policy indicator. Section 5 presents our main results and discusses possible theoretical explanations. Section 6 presents various robustness checks. Finally, Section 7 provides concluding remarks.

2. Related Literature

Our study is most closely related to the contributions of Acharya, Engle, and Pierret (2014), Acharya and Steffen (2015), Bonner (2016), and Gropp et al. (2019), who use bank-level data and microeconometric tools to investigate the effects of macroprudential policy on banks' demand for sovereign bonds. Acharya, Engle, and Pierret (2014) and Gropp et al. (2019) analyze the results of the European Banking Authority (EBA) stress tests on large European banks in 2011. Acharya, Engle, and Pierret (2014) conclude that the way the weights are assigned has provided perverse incentives to build up exposures to low-risk-weight assets such as domestic sovereign bonds. Gropp et al. (2019) find that banks confronted with higher capital requirements increased their sovereign exposures relative to other banks. Focusing on the Netherlands, Bonner (2016) shows that the revision of regulations regarding liquidity and capital requirements in 2011 caused Dutch banks to increase their demand for government bonds beyond their internal risk management targets, while reducing their holdings of other bonds. Acharya and Steffen (2015) show that, in the period 2010–12, European banks with a relatively low tier 1 capital ratio had a stronger incentive, relative to their better capitalized counterparts, to increase their return on equity by investing in the bonds issued by the governments of Greece, Ireland, Italy, Portugal, and Spain, as these bonds offered high yields but were subject to zero regulatory risk weights. We differ from these analyses by adopting a purely macroeconomic perspective. Moreover, we explore the average effects of a broad set of capital-based macroprudential policy measures over a longer period instead of focusing on a particular event.

Our paper also fits into a broader literature exploring the potential determinants of the sovereign-bank nexus. In particular, banks might be exposed to *moral suasion*, that is, pressure from the government on banks to invest more in domestic public debt (Altavilla, Pagano, and Simonelli 2017; Becker and Ivashina 2018; Dell'Ariccia et al. 2018; Ongena, Popov, and van Horen 2019). Moreover, banks are often unrewarded for holding a balanced sovereign portfolio, as rating agencies tend not to rate them above their sovereign in any case (Bilbiie, Monacelli, and Perotti 2021). Several studies have also shown that unconventional monetary policy interventions incentivize banks in some euro-area countries to hold more domestic public debt (Acharya and Steffen 2015; Crosignani, Faria-e Castro, and Fonseca 2020; Carpinelli and Crosignani 2021; Hristov, Hülsewig, and Scharler 2021; Peydró, Polo, and Sette 2021), for example by reinforcing the tendency toward *gambling for resurrection* (Drechsler et al. 2016). Euro-area banks also seem to increase their exposure to domestic sovereign bonds in response to a rise in the perceived solvency risk of the government (Battistini, Pagano, and Simonelli 2014). Furthermore, sovereign securities are held for the purpose of liquidity management as well as being a source of collateral and returns (Dell'Ariccia et al. 2018). We contribute to this literature by considering the effects of macroprudential policy on the sovereign-bank nexus.

From a methodological perspective, our work is also related to several contributions that use macroeconomic data and similar time-series techniques to analyze the transmission of shocks on banks' capital ratio or unexpected changes in capital regulation (Berrospide and Edge 2010; Behn, Gross, and Peltonen 2016; Gross, Kok, and Zochowski 2016; Noss and Toffano 2016; Meeks 2017; Eickmeier, Kolb, and Prieto 2018; Kanngiesser et al. 2020; Budnik and Rünstler 2023). The majority of these studies find that a shock pushing the actual or regulatory capital ratio upward, or the buffer downward, is associated with a significant decline in lending growth and economic activity in the short run.[4] However, unlike our analysis, all these papers are silent about the possible effects of the shock on banks' exposure to domestic sovereign debt.[5]

[4]Exceptions are Berrospide and Edge (2010), who find the opposite for the U.S., and Gross, Kok, and Zochowski (2016), where three different types of capital-ratio shocks are considered, each leading to different responses of lending and real activity.

[5]There are numerous other studies that empirically examine the effectiveness of different types of macroprudential instruments and their channels of transmission, however, without considering any potential effects on the sovereign-bank nexus. See Bakker et al. (2012), Claessens, Ghosh, and Mihet (2013), Crowe et al. (2013), Maddaloni and Peydró (2013), Acharya, Engle, and Pierret (2014),

3. Methodology and Data

3.1 Empirical Model

We use a panel VAR model in reduced form:

$$y_{k,t} = \sum_{j=1}^{p} B_j y_{k,t-j} + c_k + \varepsilon_{k,t}, \tag{1}$$

where $y_{k,t}$ is a vector of endogenous variables for country k, B_j is a matrix of autoregressive coefficients for lag j, p is the number of lags, c_k is a vector of country-specific intercepts that account for possible heterogeneity across the units, and $\varepsilon_{k,t}$ is a vector of reduced-form residuals. We refer to a policymakers' macroprudential reaction function regarding the selection of endogenous variables. Specifically, our baseline model includes five variables: (i) an indicator of *capital-based* macroprudential policy measures, hereafter denoted as MPI, (ii) the banks' domestic government bond holdings ratio, which serves as an indicator for the sovereign-bank nexus, (iii) the credit-to-GDP gap, (iv) a lending spread, and (v) an indicator of financial stress.

For every element of $y_{k,t}$, we use a pooled set of $M \cdot T$ observations, where M denotes the number of countries and T the number of observations. For each cross-sectional unit, the reduced-form residuals are assumed to be normally distributed with a homogeneous variance-covariance matrix Σ, that is, $\varepsilon_{k,t} \sim \mathcal{N}(0, \Sigma)$. After stacking $\varepsilon_{k,t}$ into a vector $\varepsilon_t = [\varepsilon'_{1,t} \ldots \varepsilon'_{M,t}]'$, we obtain $\varepsilon_t \sim \mathcal{N}(0, I_M \otimes \Sigma)$, where I_M is an identity matrix of dimension M.

Following Ciccarelli, Maddaloni, and Peydró (2015), we adopt panel techniques. We consider two country groups, that is, the peripheral countries including Ireland, Italy, Portugal, and Spain, and core countries comprising Austria, Belgium, Finland, France, Germany, and the Netherlands. Estimating panel models allows us

Bridges et al. (2014), Vandenbussche, Vogel, and Detragiache (2015), Kuttner and Shim (2016), Bruno, Shim, and Shin (2017), Cerutti, Claessens, and Laeven (2017), Jiménez et al. (2017), Kim and Mehrotra (2017, 2018, 2022), Akinci and Olmstead-Rumsey (2018), Cizel et al. (2019), Richter, Schularick, and Shim (2019), Budnik (2020), Poghosyan (2020), and Acharya et al. (2022). VanHoose (2007, 2008), Claessens (2015), and Galati and Moessner (2018) provide comprehensive literature surveys.

to pool the diverse information from the two country groups while controlling for heterogeneity across the units by considering country-specific fixed effects. One main advantage of this approach is that it increases the efficiency of statistical inference. Every panel model is estimated for the period from 2005:Q1 to 2018:Q4.[6]

Our variable selection is based on the notion that, for the purpose of safeguarding financial stability, macroprudential policy is supposed to react to potentially undesirable developments in indebtedness, financial conditions, and the likelihood (or even materialization) of financial stress.[7] In particular, positive values of the *credit-to-GDP gap* can be interpreted as indicating excessive, potentially unsustainable credit expansion, which is a frequent precursor of crises. Drehmann, Borio, and Tsatsaronis (2011), Gourinchas and Obstfeld (2012), Jordà, Schularick, and Taylor (2013), and Drehmann and Juselius (2014) document the gap's excellent properties as a financial-crisis predictor.[8] Moreover, the credit-to-GDP gap is an integral part of policymakers' decisions regarding adjustments of the countercyclical capital buffer (CCyB) and is the only indicator explicitly incorporated into CCyB legislation in the euro-area countries (BCBS 2010). Low *credit spreads* might indicate excessive risk appetite, which in turn might bring about misallocations of credit and thus higher financial fragility (IMF 2019; ESRB 2021). Krishnamurthy and Muir (2017) show that normalized credit spreads—defined as the difference between high-yield and low-yield corporate bonds—have significant predictive power regarding financial crises. López-Salido, Stein, and Zakrajšek (2017) discuss the

[6]Our set of countries comprises all EMU founding members with the exception of Luxembourg, which is not included due to its small size. As Greece joined the monetary union in 2001, it would also have been a possible candidate for our analysis over the sample period 2005:Q1–2018:Q4. However, we exclude Greece because it received external funding during the course of the European sovereign debt crisis, that is from May 2010 and thereafter, mainly through euro-area financial aid programs. Public borrowing through capital markets was severely restricted, while capital controls were put in place at the same time. This likely distorts the effects of macroprudential regulation on the sovereign-bank nexus in our sample period.

[7]See, for example, Angelini, Neri, and Panetta (2014), Benes and Kumhof (2015), and Boar et al. (2017) as well as ESRB (2019a, 2021, 2022) and ECB (2022).

[8]Using the credit-to-GDP measures proposed by Hamilton and Leff (2020) instead of the Basel gap has no effect on our results. See Section 6 for a discussion.

predictive power of spreads regarding economic downturns. Elevated levels of *financial stress* might incentivize policymakers to release some capital buffers or at least postpone further macroprudential tightenings in an attempt to attenuate a potential contraction in credit supply (ESRB 2021). However, as suggested by Adrian et al. (2022), a prolonged spell of compressed financial stress might also signal the gradual buildup of financial vulnerabilities which might increase downside risks for the economy in the medium run. There is also another reason why it appears important to control for financial stress in the current context. In times of financial turbulence, banks—especially distressed ones—might increase their holdings of domestic sovereign bonds due to *moral suasion* by national governments or incentives to engage in *carry trades* or *gambling for resurrection*.

Clearly, there is a plethora of other indicators which might potentially also shape macroprudential policy decisions. However, to maintain sufficient degrees of freedom, we choose a parsimonious specification for our baseline VAR which nevertheless includes the most prominent variables considered in the pursuit of financial stability. In Section 6.3, we extend the VAR by including additional indicators reflecting asset price developments, sovereign yields, and financial conditions.[9] Finally, the period we consider largely coincides with an episode characterized by a series of unconventional monetary policy measures in the euro area and an associated substantial expansion of the ECB's balance sheet. As shown by Hristov, Hülsewig, and Scharler (2021), these nonstandard interventions also affect the sovereign-bank nexus. In Section 6.2, we explicitly include indicators of monetary policy in the VAR and assess the robustness of our baseline results.

In estimating separate panel VAR models for the two country groups, we allow for possible structural heterogeneities across entities. Such heterogeneities appear a priori likely given the differences in economic development before and after the Global Financial Crisis. All countries in the euro area fell into recession because of the

[9]Moreover, we extend the VAR model by including additional macroeconomic variables, that is, real output and the gross domestic product (GDP) deflator. See Appendix B.1 for the results.

Global Financial Crisis. However, in peripheral countries, the economic slack was more pronounced because of a substantial loss of international price competitiveness, a deterioration of the banking sector's health, and a strong increase in private or public debt. In addition, sovereigns in peripheral countries faced difficulties in tapping international capital markets during the European sovereign debt crisis, which arose between 2010 and 2013, leading to extraordinary fiscal distress. As explained in the Introduction, the unfavorable situation was likely exacerbated by the emergence of *doom loops* due to the sovereign-bank nexus. Consequently, Ireland, Italy, Portugal, and Spain were forced to adopt substantial cyclical and structural adjustments in fiscal policy and launch far-reaching structural reforms in goods and labor markets. In contrast, core countries faced comparatively moderate recessions, benefited from their *safe-haven* status, and were not forced to undertake noteworthy structural reforms.

3.2 Data

The credit-to-GDP gap is provided by the Bank for International Settlements (BIS) based in Basel, and is therefore also referred to as the *Basel gap.* It is defined as the trend deviation of the ratio of total credit to the nonfinancial private sector to GDP. The trend is obtained using a *one-sided* Hodrick-Prescott filter with a smoothing parameter of 400,000.[10]

The remaining macroeconomic data are obtained from the ECB and collected on a quarterly basis.[11] The lending spread is calculated as the difference between the loan rate and the three-month EURIBOR (euro-area interbank offered rate), where the loan rate is derived as the volume-weighted average of the loan rate on loans extended to nonfinancial corporations and the loan rate on mortgage loans. The Country-Level Index of Financial Stress (CLIFS) is used as an indicator of financial market tension. Finally, we consider the share of banks' capital position, total loans, and foreign government bond holdings to total assets. The series are transformed from monthly to quarterly frequencies where necessary.

[10]The definition of the credit-to-GDP gap is the one proposed by Drehmann, Borio, and Tsatsaronis (2011) and Drehmann and Juselius (2014), among others.

[11]See Appendix A for a detailed description of the data.

The MPI is derived from the Macroprudential Policy Evaluation Database. Its construction is explained below. Finally, note that we consider the period from 2005:Q1 to 2018:Q4, since the implementation of macroprudential policy measures was substantially more limited before 2005, and the macroprudential database did not extend beyond the end of 2018.[12]

3.3 Identification of Structural Macroprudential Policy Shocks

We estimate the panel VAR model (1) with Bayesian methods using a normal-Wishart prior for the parameters. Inference is based on 10,000 draws from the corresponding posterior distribution. We set the lag order to four, that is, $p = 4$, which accounts for possible delays in the interaction between the macroeconomic variables and macroprudential policy. Based on the outcome of the estimated model, we generate impulse responses of the variables to the structural shocks $\eta_t = [\eta'_{1,t} \cdots \eta'_{M,t}]'$, where $\eta_{k,t} \sim \mathcal{N}(0, I_N)$ and $\eta_t \sim \mathcal{N}(0, I_{N \cdot M})$. The relationship between $\eta_{k,t}$ and the reduced-form residuals is governed by $\varepsilon_{k,t} = A_0 \eta_{k,t}$, which holds for each cross-sectional unit $k = \{1, ..., M\}$ and $\Sigma = A_0 A_0'$.

We identify a structural shock related to macroprudential policy by imposing a recursive ordering on $y_{k,t}$. This is implemented by assuming that the matrix A_0 corresponds to the lower triangular element in the Cholesky factorization of the variance-covariance matrix Σ of ε_t. The MPI is ordered *first* and the corresponding orthogonal disturbance is interpreted as capturing the unsystematic/exogenous component of macroprudential policy. The ordering implies that the latter reacts only to its own shock on impact, while responding to all other shocks with a lag of at least one quarter. This identification scheme is guided by the observation that macroprudential policy, unlike monetary policy, tends to be rather slow-moving. In particular, the adjustment of macroprudential instruments suffers from substantial *inaction bias* and *implementation lags.* Various factors contribute to this delayed responsiveness. Firstly, political-economic constraints, such as the costs of prudential interventions, are felt

[12]Note that due to limited sample size, we cannot undertake subsample analysis. However, we show robustness of our results to different starting dates of our sample in Section 6.4.

immediately, while the potential benefits only appear in the long run (Arslan and Upper 2017). Secondly, the final objective of *financial stability* is barely quantifiable because the available tools to proxy the financial cycle or systemic risk are still underdeveloped (see, e.g., Lim et al. 2011, Knot 2014; Arslan and Upper 2017; Dagher 2018; Edge and Liang 2020, 2022). Thirdly, in many countries multiple institutions are simultaneously responsible for prudential regulation, which might protract the decision-making process, particularly if the responsible bodies meet infrequently (Edge and Liang 2020, 2022). Finally, the adjustment of many macroprudential instruments, especially capital-based instruments, is preceded by a phase-in period of several quarters. Nevertheless, we check the robustness of our results to alternative Cholesky orderings, thus allowing macroprudential policy to react on impact to more or even all shocks hitting the system.

4. Macroprudential Policy Indicator

4.1 Macroprudential Policy Database

We resort to the Macroprudential Policy Evaluation Database (MaPPED) provided by Budnik and Kleibl (2018) to measure changes in macroprudential policy. The database was constructed by central bank experts in charge of prudential oversight and regulation. The focus is on the EU member states, including the U.K., and comprises information on 1,925 policy actions. Relative to other macroprudential databases, MaPPED has the advantage that each policy action is given a very detailed description, the latter being represented by a finite set of items and subitems, which are the same across policy actions and countries. Of particular importance is that, for each macroprudential measure, MaPPED tracks the full set of corresponding policy changes over time, that is, the dates of announcement, actual implementation, subsequent upward or downward adjustments, and (potential) deactivation. Several other existing macroprudential databases, while having the clear advantage of covering a broader set of advanced and emerging economies, either only contain the date a measure entered into force but are silent about announcements, and subsequent tightening or loosening, or only allow for a less detailed and, in some cases, an arguably more subjective categorization of each measure.[13] Alternatively, the Integrated Macroprudential Policy (iMaPP) database collected by Alam et al. (2019) also provides a relatively detailed categorization of the individual measures included. However, regarding the EMU countries we consider, the number of capital-based policy interventions in the period before 2013 contained in iMaPP is much smaller than in MaPPED. As capital-based policy is the main focus of our analysis, we refer to MaPPED in our baseline specification while resorting to iMaPP in a robustness check (see Appendix B.2).

Table 1 presents descriptive summary statistics from MaPPED for the euro-area countries in our sample. The numbers refer only to those policy changes characterized as *legally binding.* Interventions described as mere *recommendation or guidance* are excluded, because, in our view, they are less likely to induce changes in economic behavior. The table further covers only the policy actions classified as either *tightening* or *loosening.* The remaining actions, described as *unspecified or with an ambiguous impact,* are discarded.

Regarding our two country groups, core and periphery, we classify the different types of policy changes into four broader categories. *Capital based* covers the policy changes 1–4 which are directly related to the balance sheets of financial institutions (predominantly banks). *Borrower based,* corresponding to policy measure 5, denotes interventions affecting the credit standards applied by banks. *Liquidity* corresponds to policy measure 6 and covers policy actions affecting the liquidity position of banks as well as maturity and currency mismatches. *Other* comprises levies and taxes on financial institutions, limits to exposures and concentrations, and other measures. Finally, rows 10, 11, and 12 show the sum of all capital-based and non-capital-based policy actions, respectively.

The majority of interventions belong to the class of capital-based measures. As revealed by column b.1 in Table 1, in core countries the share of these measures in all interventions amounts to 46.2 percent, while in peripheral countries the share is 67.1 percent. The most frequently changed capital-based measures are adjustments to minimum capital requirements, followed by changes in risk weights and capital buffers; see rows 3, 4, and 1. In contrast, the shares of

[13] See the macroprudential databases used by Lim et al. (2011), Kuttner and Shim (2016), and Cerutti et al. (2017) for an example.

Table 1. Macroprudential Policy Changes between 1999 and 2018: Descriptive Evidence

Type of Policy Change	**Number of Policy Changes**		**Relative Frequency of Each Policy Type**		**Fraction of Tightening within Each Policy Type**	
	Countries		**Countries**		**Countries**	
	Core (a.1)	**Periphery (a.2)**	**Core (b.1)**	**Periphery (b.2)**	**Core (c.1)**	**Periphery (c.2)**
Capital-Based:						
1. Capital Buffers	17	10	12.9%	13.7%	100%	100%
2. Loan-Loss Provisioning	2	5	1.5%	6.9%	50%	80%
3. Min. Cap. Requirements	26	22	19.7%	30.1%	100%	100%
4. Risk Weights	16	12	12.1%	16.4%	56.3%	75%
Borrower-Based:						
5. Lending Standards Restrictions	19	1	14.4%	1.4%	94.7%	0%
Liquidity:						
6. Liquidity Requirements	16	8	12.1%	11.0%	100%	87.5%
Other:						
7. Levy/Tax on Financial Institutions	15	2	11.4%	2.7%	73.3%	100%
8. Limits on Exposures	14	9	10.6%	12.3%	64.3%	77.8%
9. Other Measures	7	4	5.3%	5.5%	71.4%	100%
Sum:						
10. All Measures	132	73	100%	100%	84.8%	89.0%
11. Capital-Based	61	49	46.2%	67.1%	86.9%	91.8%
12. Non-Capital-Based	71	24	53.8%	32.9%	83.1%	83.3%

Note: Only policy changes characterized as (i) *legally binding* and (ii) either *tightening* or *loosening*. Policy interventions with *unspecified or ambiguous impact* are excluded. The values in row 10 (All Measures), in row 11 (Capital-Based), and in row 12 (Non-Capital-Based) correspond to the column-by-column sum over policy changes in rows 1–9, rows 1–4, and rows 5–9, respectively.

measures characterized as borrower-based, liquidity requirements, levies/taxes and limits to exposures are much smaller; see rows 5–8. Irrespective of their type, the bulk of policy actions are tightening measures; see columns c.1 and c.2.

Overall, Table 1 reveals the substantial diversity of different types of macroprudential measures. Some of them operate on the asset side of financial institutions (e.g., "risk weights" or "limits on exposures and concentration") whereas others directly target the liability side (e.g., "capital buffers" and "minimum capital requirements"). The majority of borrower-based instruments affect banks' balance sheets only indirectly, whereas most other measures exert a direct effect. Some measures operate on flows or transactions (e.g., many financial taxes) while others impose restrictions on stocks. Accordingly, the different types of macroprudential policy interventions might be transmitted differently through the financial system and potentially have different consequences for banks' sovereign exposures. Ideally, one would assess the potential effects of each individual measure type, that is, 1–9, separately. Unfortunately, this would render econometric analysis infeasible, as the number of policy actions within each measure type is very small. This could increase estimation uncertainty and potentially bias the results because of insufficient variation in the macroprudential policy variables over time and across countries.

Considering the heterogeneity of instruments and the aforementioned potential econometric problems, we decided to focus our subsequent analysis on the class of "capital-based" measures, which aggregate over instrument types 1–4. This appears warranted, as these measure types, while not homogeneous, exhibit the similarity of directly affecting banks' regulatory capital requirement. Consequently, our estimates presented in the following reflect the transmission of unsystematic shifts in (shocks to) the *average capital-based policy instrument* rather than in any of the individual instrument types 1–4.[14] In contrast, the remaining non-capital-based macroprudential measures, that is, 5–9, appear too diverse to be meaningfully bundled.

[14]In Section 6.1, we show that our results do not depend on any of the subcategories 1–4.

4.2 Construction of the Capital-Based Macroprudential Policy Indicator

We follow the majority of existing studies and construct MPI as a discrete "dummy-type" indicator based on the *capital-based* policy changes.[15] In particular, the indicator comprises adjustments in the MaPPED categories (i) "capital buffers," (ii) "loan-loss provisioning," (iii) "minimum capital requirements," and (iv) "risk weights" (see Table 1).[16] We assign each individual policy change a value of +1 if it was a tightening, a value of –1 if it was a loosening, and zero if the intervention is characterized as "unspecified or with ambiguous impact." In case a country reports more than one policy change in a particular quarter, the associated discrete values are simply added up to arrive at the period-specific policy change indicator $PolChange_{k,t}$ for country k and period t.[17] In periods without capital-based macroprudential policy changes, we have $PolChange_{k,t} = 0$. Next, given $PolChange_{k,t}$, we construct MPI for country k as the cumulative sum of $PolChange_{k,t}$:

$$MPI_{k,t} = MPI_{k,t-1} + PolChange_{k,t} = \sum_{j=0}^{j=t} PolChange_{k,j}.$$

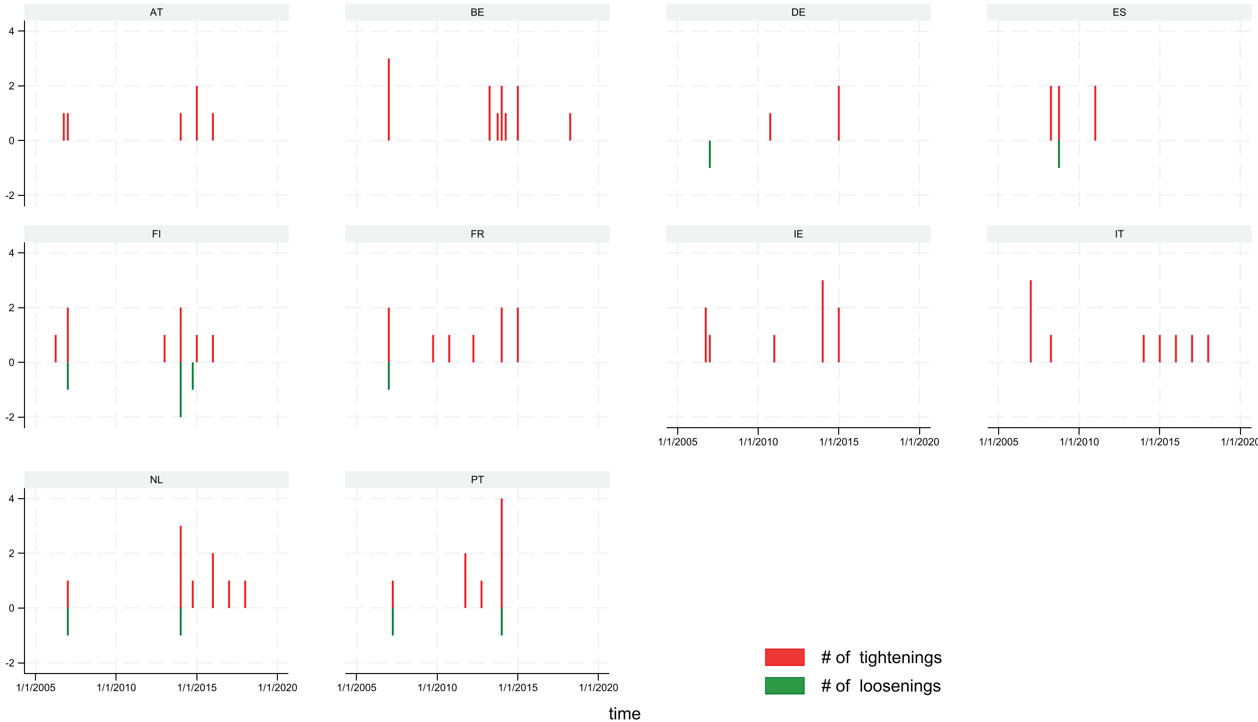
The resulting country-specific cumulative $MPI_{k,t}$s are shown in Figure 1 along with the number of tightening and loosening measures. $MPI_{k,t}$ implies that each capital-based policy change has a potentially permanent effect on the indicator. In other words, after a policy tightening, the MPI remains higher until the policy change

[15] See Claessens, Ghosh, and Mihet (2013), Kuttner and Shim (2016), Boar et al. (2017), Bruno, Shim, and Shin (2017), Cerutti, Claessens, and Laeven (2017), Akinci and Olmstead-Rumsey (2018), Altunbas, Binici, and Gambacorta (2018), Gambacorta and Murcia (2019), and Poghosyan (2020), among others.

[16] There is an additional category that might be considered here, "leverage-ratio restrictions." However, for the countries in our sample, MaPPED does not include changes in the regulation of banks' leverage ratios which are classified as either tightening or loosening in this category.

[17] Several interventions simultaneously contain a tightening and loosening element, as when risk weights are increased for a particular loan type, but loosened for others. For example, the Netherlands reported four tightenings and one loosening in 2014:Q1. Thus, the policy change indicator for this period is $4-1 = 3$.

Figure 1. Historical Evolution of Capital-Based Macroprudential Policy



Note: The bars show the number of tightenings and loosenings of capital-based instruments.

is reversed or compensated for by the loosening of another capital-based instrument. Accordingly, the cumulative MPI is more suitable for reflecting the evolution of the overall tightness of capital-related macroprudential policy rather than the time series of period-by-period policy changes $PolChange_{k,t}$ (Akinci and Olmstead-Rumsey 2018; Meuleman and Vander Vennet 2020).

An important property of our MPI is that it implies a fully equivalent treatment of capital-based policy actions across types and magnitudes. We do not attempt to capture the (possibly time-varying) intensity of a measure or weigh measures based on the degree of their bindingness. Accordingly, dummy-type MPI only reflects the *extensive margin* of capital-based interventions, that is, their frequency and direction, but not their *intensive margin*. Ideally, one would like to measure the intensity of these policies. However, it is not straightforward to obtain a fully quantitative policy indicator due to the limited comparability across countries and across measures (Kuttner and Shim 2016; Cerutti et al. 2017; Akinci and Olmstead-Rumsey 2018; Alam et al. 2019).[18] In the face of this issue and given our objective of analyzing a panel of euro-area economies, we restrict our analysis to the dummy-type indicator which, notwithstanding its limitations, allows for a sufficient degree of comparability across countries.

However, as pointed out by Akinci and Olmstead-Rumsey (2018), the use of a dummy-type MPI generates an attenuation bias for the coefficient estimates on the indicator.[19] Accordingly, our results presented below should be viewed as conservative, being biased toward a lower likelihood of finding a significant relationship between changes in capital-based macroprudential regulation and other macroeconomic variables.

[18] In particular, due to differences between the national legal frameworks, even seemingly similar capital-based measures are often implemented differently and applied to different objects (e.g., specific types of loans) across jurisdictions. The same holds within a given country.

[19] The attenuation bias stems from measurement error, as the indicator is an imperfect measure of the strength of macroprudential regulation. This measurement error worsens if one cannot perfectly distinguish between binding and nonbinding measures, as is the case here.

5. Results

5.1 Impulse Responses to Macroprudential Policy Shocks

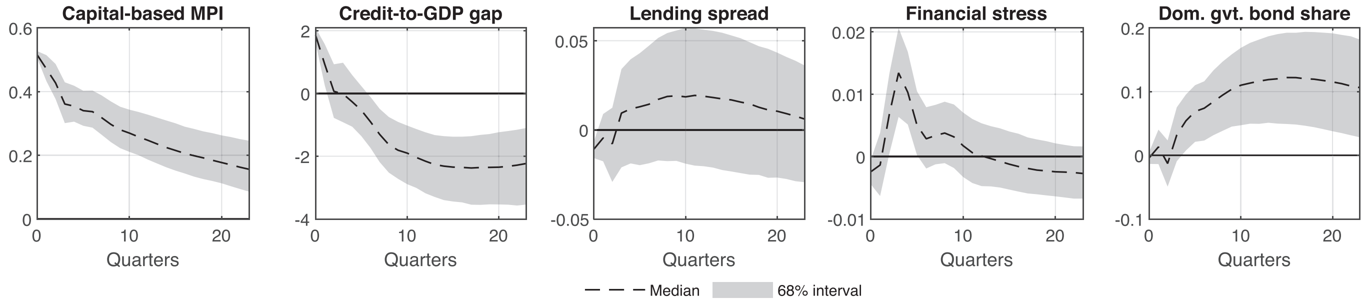
For the two country groups, Figure 2 summarizes the impulse responses of the variables in the baseline model to a shock that reflects an unexpected tightening of macroprudential capital regulation. The responses of the peripheral countries are shown in the top row, those of the core countries in the bottom row. The median impulse responses are depicted by the dashed lines. The shaded areas indicate the 68 percent credibility bound.

In both country groups, the Basel gap displays a significant and persistent decline after a limited short-lived rise. Given that the credit-to-GDP gap is widely viewed as an indicator of systemic financial vulnerability, our result suggests that a sudden tightening in capital-based macroprudential policy is effective in reducing excessive leverage in the nonfinancial private sector and, thus, systemic risk. The lending spread, that is, the spread between the loan rate and the three-month EURIBOR, tends to increase after the macroprudential impulse. In core countries, the change is significant. The reactions of the Basel gap and lending spread indicate the presence of adverse loan supply effects (Altavilla, Darracq Pariès, and Nicoletti 2019). In addition, in peripheral countries, the level of financial stress increases significantly in the short run. In core countries, on the other hand, financial stress falls below average values in the longer term.

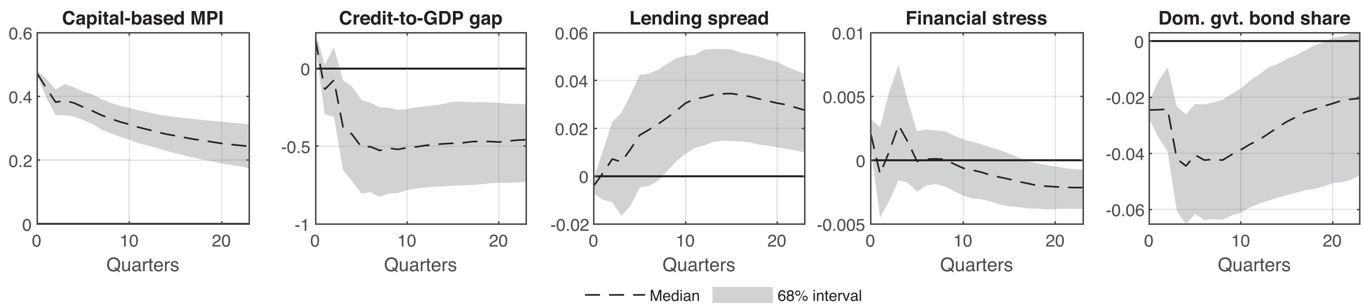
Next, we turn to the main focus of our analysis, that is, the response of the share of domestic government bonds in banks' portfolios to unsystematic changes in capital-based macroprudential policy. We observe a notable difference between the two groups of countries. In peripheral countries, banks increase their exposure to domestic government debt. The domestic government bond holdings ratio rises significantly after the innovation. This suggests that banks' interconnectedness with their sovereign, that is, the sovereign-bank nexus, strengthens following a tightening in capital-based measures. In contrast, in core countries, the share of domestic government bonds exhibits a significant drop, thus indicating a weakening of the nexus.

Figure 2. Response of Baseline Variables to a Macroprudential Policy Shock Policy

A. Peripheral Countries



B. Core Countries



Note: Median impulse responses are depicted by the dashed lines. The shaded areas represent the 16th and 84th percentiles of the posterior distribution. Responses of the Basel gap, domestic government bond share, and lending spread in percentage points, financial stress in percent, and MPI dimensionless.

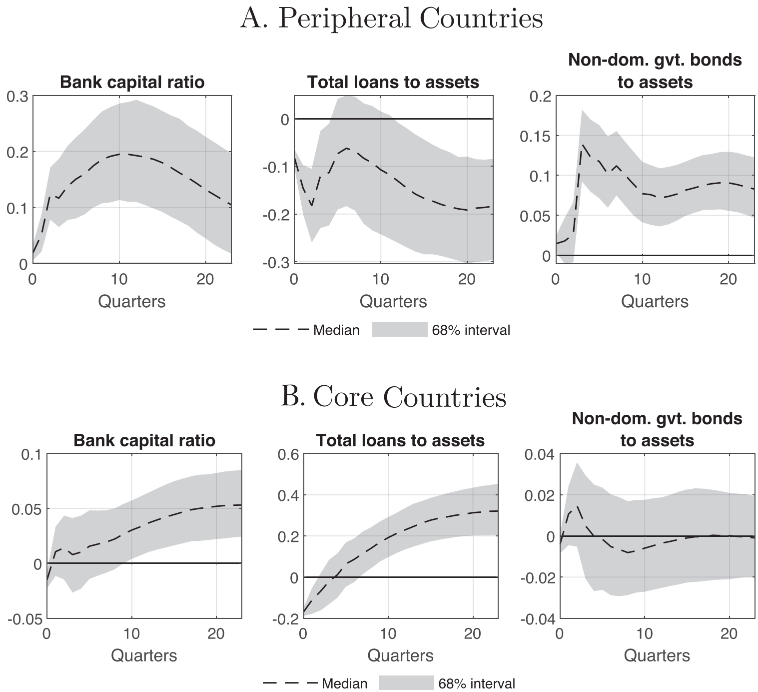
Overall, the results suggest that the quantitative effects of a shock to macroprudential capital regulation are not negligible. An average tightening in the MPI reduces the credit-to-GDP gap in peripheral countries by more than 2 percentage points (pp) after three years. Moreover, the shock leads to an increase in the domestic government bond share peaking at 0.12 pp after around three years. In core countries, the responses of the credit-to-GDP gap and the share of domestic government bonds are more moderate. The former variable falls by approximately 0.5 pp and the latter by around 0.04 pp after around one year. Given that the MPI amalgamates the capital-based regulatory changes of different varieties and across different countries, our estimates correspond to the effects of the *average* capital-based macroprudential measure, where the averaging is across different measure types of potentially different magnitudes. Accordingly, it is difficult to interpret the quantitative effects of a restrictive shock to capital regulation precisely. Therefore, in the following, we focus on the qualitative effects of capital-based macroprudential regulation, while noting that the quantitative effects appear economically significant.

Adjustment of Other Bank Balance Sheet Positions. We now examine the responses of other bank balance sheet items to a restrictive capital-based regulatory shock. In particular, we estimate modified versions of our panel VAR model, each time replacing banks' domestic sovereign bond holdings ratio with either the capital ratio, the ratio of loans to total assets, or the ratio of nondomestic government bonds.

As revealed by the first two plots for each country group in Figure 3, the banks' capital ratio rises in response to an unsystematic tightening of capital-based macroprudential policy. This indicates that such policy interventions tend to be effective not only in reducing systemic financial vulnerability as proxied by the Basel gap but also in increasing the loss-absorption capacity due to a higher capital ratio. Thus, the banking sector's resilience is strengthened.

Moreover, the second column of Figure 3 shows that banks' loan volume in peripheral countries declines relative to total assets after a shock to capital-based macroprudential policy. By contrast, in core countries, the corresponding ratio increases, albeit after a short-lived initial decline. The response of the nondomestic sovereign bond holding ratio also differs across the two country groups. In peripheral

Figure 3. Response of Banks' Balance Sheet Items to a Macroprudential Policy Shock



Note: Median impulse responses are depicted by the dashed lines. The shaded areas represent the 16th and 84th percentiles of the posterior distribution. All responses in percentage points.

countries, it increases significantly, while in core countries it falls, if at all. Hence, our findings suggest that peripheral banks adjust their portfolios broadly toward a higher holding of government bonds, that is, domestic sovereign bonds as well as foreign sovereign bonds.

5.2 Theoretical Explanations

What might explain the different reactions across country groups to unsystematic changes in macroprudential policy? At first glance, the adjustments taking place in peripheral countries seem unsurprising, i.e., if the ability of banks to improve their regulatory capital position by issuing equity or via retained earnings is limited, a tightening of capital-based regulatory instruments might force them to shift their portfolios toward assets with lower risk weights, such as sovereign bonds. As noted in the Introduction, this is the concern raised by many observers regarding the possible unintended effect of macroprudential regulation on the sovereign-bank nexus. However, this is only one possible explanation, as the existing theoretical and empirical literature on the risk-shifting effects of capital regulation draws a more nuanced picture (VanHoose 2007; Galati and Moessner 2018). In the following, we discuss the *capital buffer theory,* which might contribute to explaining our findings.[20]

According to the capital buffer theory, banks choose their capital ratio optimally. The buffer corresponds to the capital held in excess of the regulatory requirement (Buser, Chen, and Kane 1981; Marcus 1984; Calomiris and Kahn 1991; Calem and Rob 1999). Banks face the trade-off between holding a higher capital buffer to reduce the probability of violating the minimum requirement and incurring higher costs, as capital is more costly than insured deposits. In the face of tightening capital requirements, banks with high capital buffers aim to maintain their buffers by increasing both their capital and portfolio riskiness. In contrast, banks with low buffers tend to rebuild their buffers by reducing the riskiness of their asset portfolios while simultaneously attempting to raise capital by issuing equity or retained earnings. Several studies provide empirical evidence in support of such behavioral patterns (see Rime 2001 for Switzerland; Heid, Porath, and Stolz 2004 for German savings banks; and Shrieves and Dahl 1992 as well as Jokipii and Milne 2011 for the U.S.).[21]

[20]There are several reasons why the theoretical explanation should be viewed as purely suggestive. First, none of the models considered exactly matches our research question and analysis. Second, we cannot test the underlying assumptions within our framework. Third, a large part of the theoretical results are based on partial-equilibrium models. As acknowledged in the corresponding studies, these results only provide rough tendencies about what might be observed at the macroeconomic level, that is, for the banking sector as a whole. Similar qualifications are warranted regarding the related empirical evidence discussed below, since existing studies do not cover the same set of countries and resort to microeconometric data and techniques.

[21]Furthermore, based on data covering 251 banks in 36 countries, Gonzalez (2005) finds evidence indicating that tightening capital-related regulation

According to the capital buffer theory, our empirical results presented in Figures 2 and 3 would be observed if banks' excess buffers tended to be elevated in core countries and relatively smaller in peripheral countries. In this case, core countries' banks would respond to a tightening of capital-based macroprudential policy by also increasing the riskiness of their portfolios, that is, by investing more in risky loans while reducing exposure to safer sovereign bonds. Banks in peripheral countries would undergo the opposite portfolio adjustment. Support for this interpretation is provided in Figure 4, which shows the average regulatory capital ratios (tier 1 and common equity tier 1) for the two country groups. In core countries, the two ratios are strictly higher over the period in which data are available.

5.3 State-Dependent Impulse Responses

Overall, the capital buffer theory suggests that banks' decisions to adjust their exposure to domestic sovereign debt in response to a tightening in macroprudential capital regulation is related to their capital position. Therefore, in the following, we estimate country-panel local projections to derive impulse responses which depend on the capitalization of a country's aggregate banking sector. The panel comprises all of the 10 EMU economies in our sample. Accordingly, the corresponding local projections reflect the reactions of the banking sector in the *average* euro-area country.

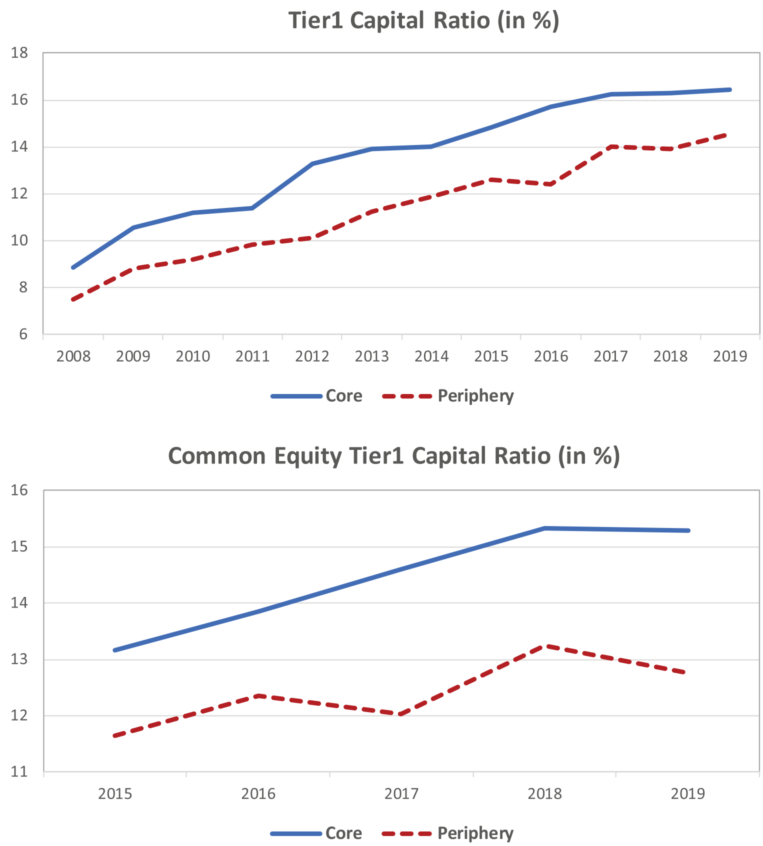
Following Jordà (2005), the panel model is given by

$$X_{k,t+h} = \theta_h MPS_{k,t} + \phi_h'(L) Z_{k,t-1} + \gamma_h EQ_{k,t-1} \times MPS_{k,t} + \alpha_{k,h} + u_{k,t+h}, \tag{2}$$

where the subindex k denotes the country, $X_{k,t+h}$ is the banks' domestic government bond ratio, $MPS_{k,t}$ is the exogenous capital-based macroprudential policy shock, θ_h is the coefficient corresponding to the shock, $Z_{k,t-1}$ is a vector of control variables, $\phi_h(L)$ is a polynomial in the lag operator, γ_h is the coefficient corresponding to

increases banks' risk-taking incentives by reducing their charter value. Moreover, this effect is significantly stronger in countries with stricter regulations, on average, since the latter tend to reduce banks' charter value by more.

Figure 4. Regulatory Capital Ratios, Averages for Each Country Group



Note: Regulatory capital as a percentage of risk-weighted assets. Weighted averages across countries in the corresponding country group. Each country-specific value is weighted by the ratio $TA_{i,t}/\sum_{i=1}^{N} TA_{i,t}$, where $TA_{i,t}$ are the total assets of country i's banks and $\sum_{i=1}^{N} TA_{i,t}$ are banks' total assets in the corresponding country group. The length of time series is restricted by data availability.
Source: ECB Statistical Data Warehouse.

the interaction between the shock and previous period's aggregate bank capital ratio $EQ_{k,t-1}$, $\alpha_{k,h}$ captures country fixed effects, and $u_{k,t+h}$ is an error term. In accordance with model (1), vector Z comprises lags of the credit-to-GDP gap, the lending spread, the CLIFS indicator, and the domestic government bond ratio. In addition, we include lags of the bank capital ratio. The macroprudential policy shock $MPS_{k,t}$ is derived from the estimated baseline model (1). The interaction term $\gamma_h EQ_{k,t-1} \times MPS_{k,t}$ allows us to gauge whether and how the reactions to the macroprudential policy shock depend on the bank equity ratio inherited from the past. The lag length is set to four. In particular, for each country and each period the shock is calculated as the mean over the 10,000 shock draws for that country and period.[22] The bank capital ratio $EQ_{k,t-1}$ corresponds to the aggregate ratio of equity to total assets. We use the method of Driscoll and Kraay (1998) to obtain heteroskedasticity-consistent standard errors that are robust to very general forms of spatial and temporal correlations. The maximum autocorrelation lag is set to $H + 1$.

We distinguish between three values of the bank capital ratio: an "average" level corresponding to the pooled panel mean, a "high" level corresponding to two standard deviations above the pooled mean, and a "low" level corresponding to two standard deviations below the pooled mean. In the case of an "average" bank capital ratio, the response of the domestic government bond ratio at time $t + h$ to an exogenous capital-based macroprudential policy shock at time t is given by the estimated sequence of coefficients θ_h over horizons $h = 0, 1, 2, 3, ...H$.[23] In the case of a "high" or a "low" bank capital ratio in period $t - 1$, i.e., in the period preceding the shock, we compute the conditional impulse response for each horizon $h = 0, 1, 2, 3, ...H$, based on Equation (2), as

$$\frac{\partial X_{t+h}}{\partial MPS_t}|_{EQ_{t-1}=EQ^*} = \theta_h + \gamma_h EQ_{t-1}, \tag{3}$$

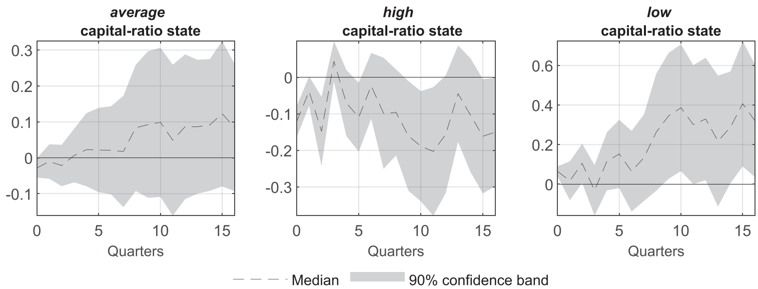
where we condition upon the capital ratio EQ_{t-1} taking the value EQ^* in $t - 1$.

For each of the three cases, the impulse responses together with the 90 percent confidence bands are depicted in Figure 5, where the

[22]The structural shocks are standardized to have a mean of zero and a standard deviation of one.

[23]In this case, the interaction term in (2) drops out.

Figure 5. State-Dependent Reaction of Banks' Domestic Government Bond Share



Note: Impulse responses of the domestic government bond share are depicted by the dashed lines. The shaded areas represent the 90 percent confidence band. The left column shows the response when the bank capital ratio of the previous period is equal to its pooled mean. The middle column shows the response when the bank capital ratio of the previous period is above its pooled mean, while the right column shows the response when the bank capital ratio of the previous period is below its pooled mean. (P) indicates impulse responses for "periphery," (C) for "core." Responses are in percentage points.

left-hand column corresponds to the "average" case in which EQ_{t-1} equals its pooled mean. As can be seen, in the average case, the reaction of the banks' domestic government bond holdings ratio to a restrictive macroprudential capital regulation shock is insignificant. This is not surprising, since in Equation (2) we pool together two country groups, i.e., core and periphery, which are heterogenous in terms of the responses of the domestic government bond holdings ratio to the shock (see Section 5.1). However, the middle column of Figure 5 shows that the response of banks' domestic government bond share becomes significantly negative when the capital ratio EQ_{t-1} is sufficiently above its pooled mean. This is qualitatively similar to our baseline result for the relatively better capitalized core countries (see Figure 2). By contrast, when EQ_{t-1} is sufficiently below average, the domestic government bond ratio rises as revealed by the right-hand panel of Figure 5. This is in line with the baseline results for the periphery countries (see Figure 2). We interpret the findings of the local-projection analysis as being consistent with the capital buffer theory. Moreover, the results suggest that the heterogeneous bank capitalization is one conceivable explanation—albeit potentially not the only one—for the heterogeneous reactions to macroprudential policy shocks across our two country groups.

6. Robustness

We assess the robustness of our results by considering several alternative model specifications. First, we examine the effects of alternative macroprudential policy indicators. Second, we assess whether our main results are affected by the explicit inclusion of indicators of monetary policy. Third, we include additional variables, such as real estate prices, government bond yields, stock market indices, and others, which are potentially important for macroprudential policy decision-making and for properly accounting for policy announcements and news. Fourth, we consider alternative sample periods. Furthermore, in Appendix B.1 we present additional robustness checks, wherein we perturb our baseline model by considering different identification schemes for the unsystematic part of macroprudential policy, detrend the MPI, add yet other control variables, and vary lags. Moreover, in Appendix B.2 we use the IMF iMaPP database for the construction of the macroprudential policy indicator as well as adjusted versions of MPI based on MaPPED. Our main results are qualitatively robust to all these checks and are quantitatively similar.

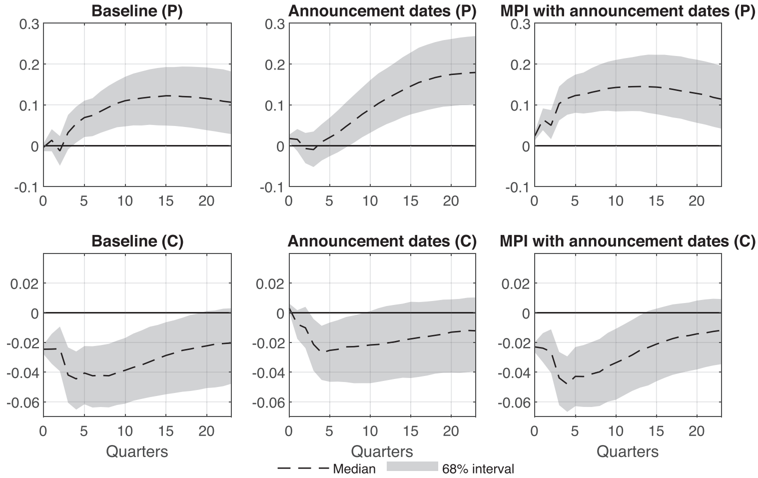
6.1 Alternative Macroprudential Policy Indicators

Announcement Effects. In our baseline analysis, we construct the MPI on the basis of actual implementation dates. However, many macroprudential interventions, even if unexpected, are announced several quarters in advance. Banks and the economy as a whole might therefore react to such announcements by starting to adjust their asset portfolios, liability structure, and general behavior well in advance of the actual policy implementation. Thus, our results might be biased because of a noninvertible VAR representation (Leeper, Walker, and Yang 2013) due to the presence of announcement effects that are not properly taken into account. In particular, a VAR based on a set of observable state variables might not be sufficient (spanning problem) to uncover the underlying structural shocks. In our case, this problem is most likely less of an issue for two reasons. First, the variables in our model and the number of lags are selected to capture the *systematic* reactions to current and future macroprudential policy measures. As the resulting Cholesky shocks in the equation of the macroprudential policy indicator $MPI_{i,t}$ are white noise, we interpret them as reflecting the unsystematic policy component. Second, Sims (2012) shows that the potential noninvertibility problem is strongly mitigated if forward-looking variables are included in the model. Our baseline model is consistent with this requirement: In particular, the CLIFS indicator condenses information from various fast-moving financial market variables such as equity returns, bond yields, and stock market volatility. Moreover, the lending spread also reflects expectations of future developments.

To provide additional evidence addressing the importance of announcement effects, we construct a capital-based MPI based on announcement rather than implementation dates, hereafter denoted by $MPI^{ann}_{k,t}$. MaPPED contains the corresponding information for approximately 70 percent of the capital-based policy actions. We perform two robustness checks. First, we estimate the VAR by replacing MPI with its announcement-based counterpart $MPI^{ann}_{k,t}$. In this case, we start our sample in 2004:Q1 instead of 2005:Q1 to keep the events approximately the same. Apart from these two changes, the model and identification scheme remain identical. The Cholesky shock to $MPI^{ann}_{k,t}$ is interpreted as the proxy for the unsystematic policy component. Second, we extend the VAR by including $MPI^{ann}_{k,t}$ as an additional variable ordered second, that is, after MPI. The Cholesky shock captures the unsystematic part of macroprudential policy; however, in this case the systematic component of macroprudential policy explicitly controls for announcements.

Figure 6 summarizes the impulse responses of the banks' domestic government bond holdings ratio under the two specifications including the announcement-based $MPI^{ann}_{k,t}$. The results are similar to those obtained previously. This indicates that each of the specifications satisfies roughly the same shock as a proxy for the unsystematic component of capital-based macroprudential policy.

Figure 6. Macroprudential Policy Announcements: Response of Domestic Government Bond Share

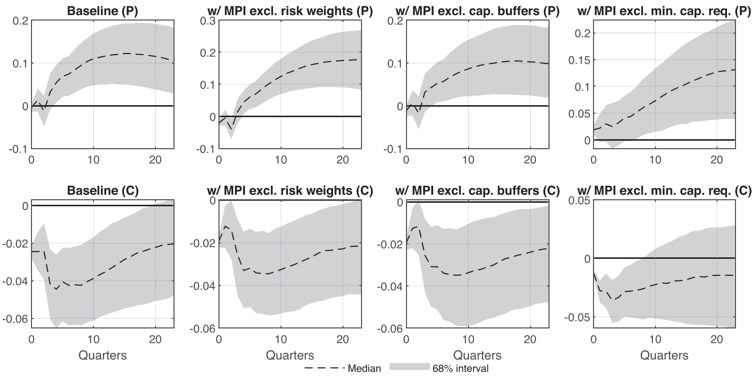


Note: Median impulse responses for the respective models are depicted by the dashed lines. The shaded areas represent the 16th and 84th percentiles of the posterior distribution. (P) indicates impulse responses for "periphery," (C) for "core." "MPI with announcement dates" refers to a VAR with six variables. Responses are in percentage points.

The Role of MPI Subcategories. Our MPI comprises four subcategories of capital-based macroprudential measures. One concern could be that these might be heterogeneous in their effects. Due to a limited number of regulatory changes in our sample, we cannot look at reactions to the subcategories individually. However, here we conduct additional analyses in order to gauge the relative importance of the different types of capital-based macroprudential measures. In particular, we construct three alternative macroprudential policy indicators, each time omitting one measure type. Creating alternative policy indicators this way—leaving out subcategories one-by-one instead of just using any one subcategory—leaves a sufficient number of observations for each country and still allows us to check whether one subcategory has a large influence on our results.

We reestimate the VAR model (1) for both groups of countries, however, using alternative macroprudential policy indicators. The alternative indicators are $MPI_{k,t}^{\text{excl. risk weights}}$, that is, excluding

Figure 7. Impulse Responses to MPI Subcategories Shocks: Response of Banks' Domestic Government Bond Share



Note: The median impulse responses are depicted by the dashed lines. The shaded areas represent the 16th and 84th percentiles of the posterior distribution. (P) indicates impulse responses for "periphery," (C) for "core." "Baseline" refers to the baseline VAR described in Section 3.1 of the paper. "MPI excl. risk weights" refers to the case where changes in *risk weights* are excluded from the definition of the MPI, that is, the $MPI_{k,t}^{\text{excl. risk weights}}$ is used. "MPI excl. cap. buffers" refers to the case where changes in *capital buffers* are excluded from the definition of the MPI, that is, the $MPI_{k,t}^{\text{excl. cap. buffers}}$ is used. "MPI excl. min. cap. req." refers to the case where changes in *minimum capital requirements* are excluded from the definition of the MPI, that is, the $MPI_{k,t}^{\text{excl. min. cap. req.}}$ is used.

adjustments in *risk weights*; $MPI_{k,t}^{\text{excl. cap. buffers}}$, that is, excluding changes in *capital buffers;* and $MPI_{k,t}^{\text{excl. min. cap. req.}}$, that is, excluding changes in *minimum capital requirements* (see Table 1). The definition of these alternative policy indicators is akin to an agnostic but extreme weighting scheme according to which one particular measure type receives a zero weight while the remaining types are assigned a positive weight.

The associated reactions of the share of domestic government bonds in banks' portfolios for each country group are shown in Figure 7 together with the baseline impulse responses. As can be seen, our results are qualitatively robust to omitting certain types of measures from the definition of the macroprudential policy indicator. Thus, we conclude that our results are not driven by a particular capital-based macroprudential policy measure.

6.2 Controlling for Monetary Policy

Several studies have shown that certain monetary policy interventions—especially unconventional ones—might incentivize banks in some euro-area countries to hold more domestic public debt.[24] In light of this evidence, we extend our baseline VAR by indicators of unconventional monetary policy. First, following Gambacorta, Hofmann, and Peersman (2014), Boeckx, Dossche, and Peersman (2017), and Hristov, Hülsewig, and Scharler (2021), we include the volume of total assets of each country's national central bank (NCB). However, some unconventional interventions conducted by the ECB over the period since 2007, like forward guidance or the announcement of the Outright Monetary Transactions (OMT) program, do not directly involve balance sheet changes and might thus be insufficiently reflected in the NCBs' total assets. Therefore, in a second robustness check, we replace the NCBs' total assets with the shadow rate constructed by Krippner (2013). The shadow rate is derived from a term structure model and attempts to proxy the true stance of monetary policy in times when conventional monetary policy is constrained by the zero lower bound and nonstandard measures of monetary policy are adopted, irrespective of whether they directly affect the Eurosystem's balance sheets. Absent unconventional interventions, the shadow rate closely follows the EURIBOR, thus also capturing conventional monetary policy.

Figure 8 shows the impulse response of banks' share of domestic government bonds to a sudden tightening of capital-based macroprudential policy for both country groups, under both indicators of monetary policy. As can be seen, the banks' reaction is virtually the same as that derived from our baseline VAR. Furthermore, the volume of NCBs' total assets rises while the shadow rate declines in response to the shock. This most likely reflects the central bank's attempt to counteract the increase in financial stress (and the credit spread in the core countries), in order to reduce the potentially associated deflationary and recessionary risks.[25]

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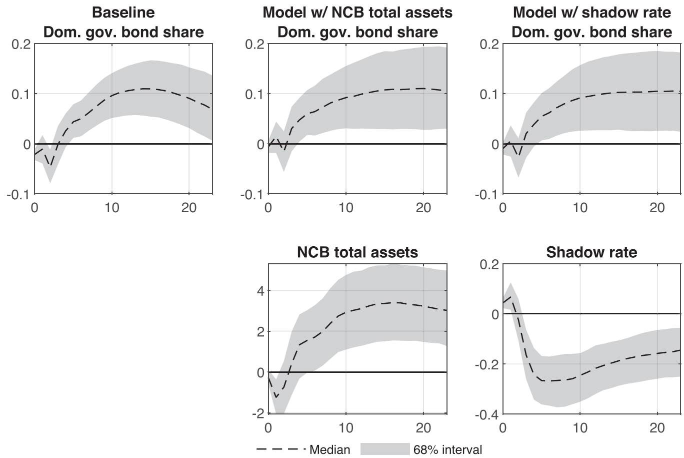
[24] See, for example, Acharya and Steffen (2015), Drechsler et al. (2016), Carpinelli and Crosignani (2021), or Hristov, Hülsewig, and Scharler (2021).

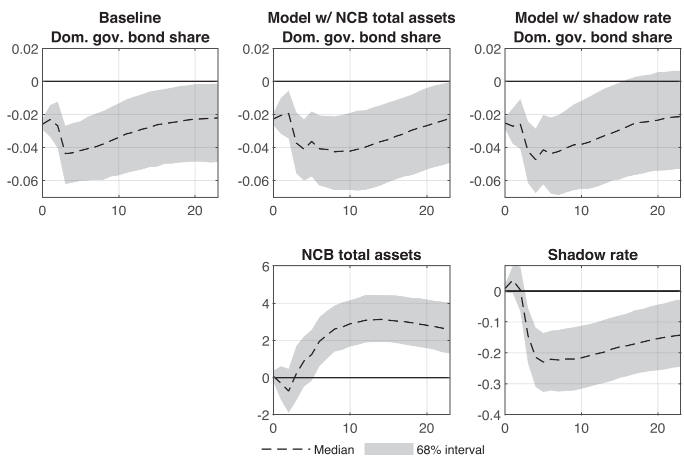
[25] These results are robust to simultaneously including both the shadow rate and the NBCs' total assets in a seven-variable VAR system. The results are available upon request.

Figure 8. Extended Panel VAR Models: Unconventional Monetary Policy

A. Peripheral Countries



B. Core Countries



Note: Impulse responses are derived from VAR systems comprising six variables. The figure shows the responses of the variables that are added to the baseline model one-by-one (bottom row), as well as the associated reaction of the domestic government bond share (top row). The first column depicts the impulse response of the domestic government bond share from the baseline model for reference. Median impulse responses are depicted by the dashed lines. The shaded areas represent the 16th and 84th percentiles of the posterior distribution. The response of NCB total assets is in percent, while the responses of all other variables are in percentage points.

6.3 Choice of Financial Indicators

Alternative Credit-to-GDP Measures. In our VAR model, we include the Basel gap, that is, the credit-to GDP gap, as an indicator of excessive, potentially unsustainable, credit expansion. The Basel gap is calculated as the deviation of the credit-to-GDP ratio from its Hodrick-Prescott filter trend (Drehmann, Borio, and Tsatsaronis 2011). However, Hamilton and Leff (2020) suggest two alternative approaches to calculate the credit-to-GDP gap, which may produce more reliable indicators measuring threats to financial stability.

Therefore, we reestimate our VAR model for both groups of countries in which we use the indicators of Hamilton and Leff (2020) instead of the Basel gap. The first indicator, denoted by *HL1*, corresponds to the residual from the following expanding sample regression on the credit-to-GDP ratio $z_{t,k}$ for each country k:[26]

$$z_{t,k} = \beta_{0,i} + \beta_{1,k} z_{t-20,k} + \beta_{2,k} z_{t-21,k} + \beta_{3,k} z_{t-22,k} + \beta_{4,k} z_{t-23,k} + \epsilon_{t,k}, \tag{4}$$

for $t = 1, 2, ... T_k$. The second indicator, termed *HL2*, corresponds to the five-year growth rate of the credit-to-GDP ratio. We find that the Basel gap is highly correlated with both Hamilton-Leff gaps. The correlation coefficients, pooled across time and all countries in our sample, are 0.59 and 0.91 for *HL1* and *HL2*, respectively.

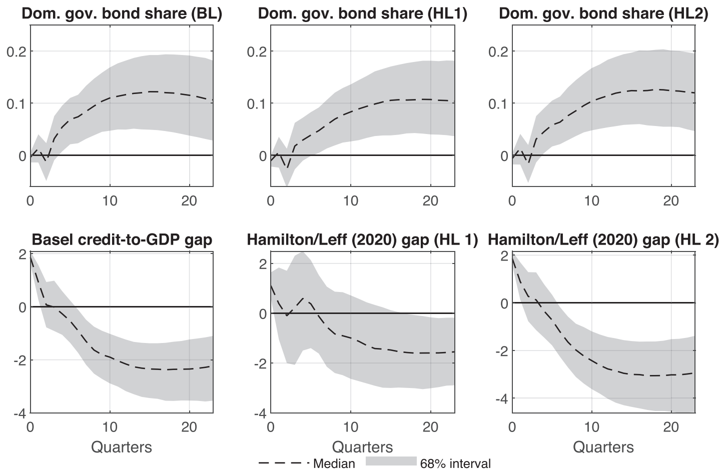
For both country groups, Figure 9 displays the impulse responses of the banks' domestic sovereign bond ratio and the corresponding Hamilton-Leff gaps to a restrictive macroprudential capital regulation shock. We observe that our main findings are confirmed both qualitatively and quantitatively. Furthermore, both Hamilton-Leff gaps *HL1* and *HL2* decline significantly in response to the shock. The choice of the credit-to-GDP gap measure thus does not seem to affect our results.

Adding Additional Financial Indicators. Next, we estimate extended versions of our panel VAR model, each including one of the following additional variables: real estate prices, that is, nominal

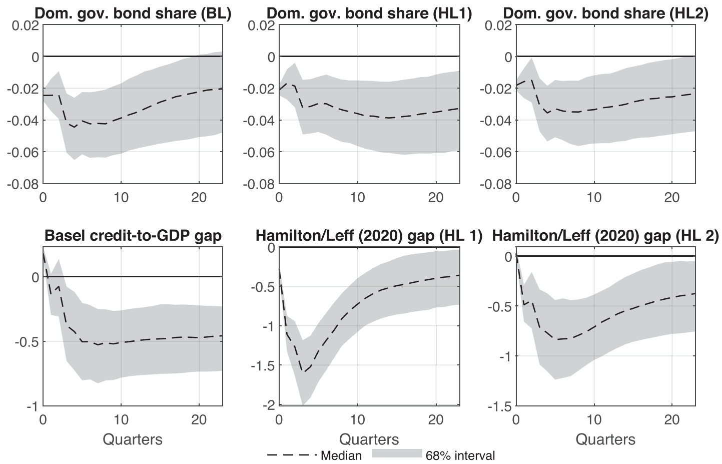
[26] Note that as suggested in Hamilton and Leff (2020), we use an expanding sample on quarterly data from 1985, allowing for sufficient degrees of freedom for the estimation of the five β coefficients even for the gap measures early in our sample starting in 2005.

Figure 9. Using Alternative Measures of the Credit-to-GDP Gap

A. Peripheral Countries



B. Core Countries



Note: The median impulse responses are depicted by the dashed lines. The shaded areas represent the 16th and 84th percentiles of the posterior distribution. The first column shows impulse responses of the baseline model including the Basel gap, denoted by *BL*. The second column shows the impulse responses derived from the model including the credit-to-GDP gap suggested by Hamilton and Leff (2020) based on expanding sample regressions, *HL1*. The third column shows the impulse responses derived from the model including the gap measure based on the five-year growth rate of the credit-to-GDP ratio, *HL2*.

house prices deflated by the GDP deflator; the bank stock market price index; the 10-year government bond yield; credit default swaps (CDS) spreads for sovereign debt; and the level of lending rates. These variables are potentially relevant for macroprudential policy, as they might signal the buildup of vulnerabilities in the real estate sector or imminent tensions in capital or credit markets.

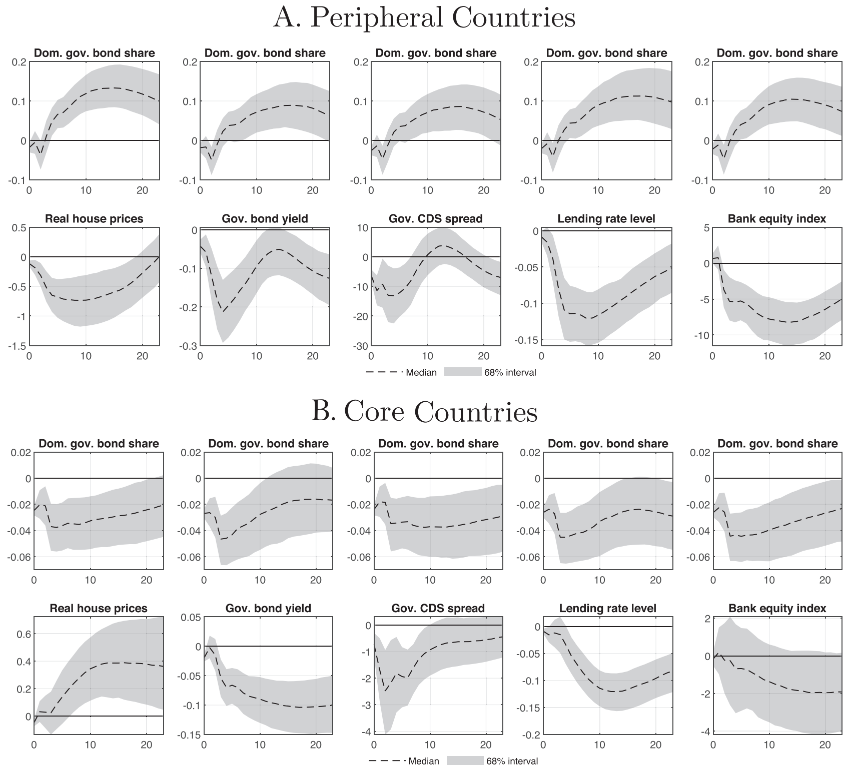
Figure 10 displays the results for the two country groups. The bottom row shows the responses of the additional variables, while the top row depicts the corresponding reaction of banks' domestic government bond share to unsystematic changes in macroprudential policy. House prices increase in the core but fall in the periphery. The government bond yield, lending rates, and CDS spreads decline significantly after the macroprudential tightening. This could be due to some signaling effect of more stable financial markets provided by the macroprudential intervention, or is likely the effect of some comovement of monetary policy.[27] Finally, the decline in the stock market price index for banks might reflect a lower expected return on equity due to the potential leverage decline induced by the regulatory tightening. The responses of the domestic government bond share in all of these specifications are again similar to those reported previously.

6.4 Alternative Sample Periods

Our analysis focuses on the period from 2005:Q1 to 2018:Q4 due to the observation that most of the capital-based macroprudential policy measures were initiated during this period. Nevertheless, it is interesting to examine whether our results also hold for alternative sample periods. For this purpose, we reestimated the baseline model for two alternative samples, that is, 1999:Q1 to 2018:Q4 and 2007:Q1 to 2018:Q4. While the first sample relates to the beginning of the euro area, the second sample covers the period since the start of the Global Financial Crisis. Figure 11 summarizes the results, which are not qualitatively affected by the choice of the sample period.

[27]Note that the decrease in government bond yields almost vanishes in the medium term in the periphery, just when the effect on the nexus, as indicated by the domestic government bond share, peaks.

Figure 10. Extended Panel VAR Models: Additional Variables

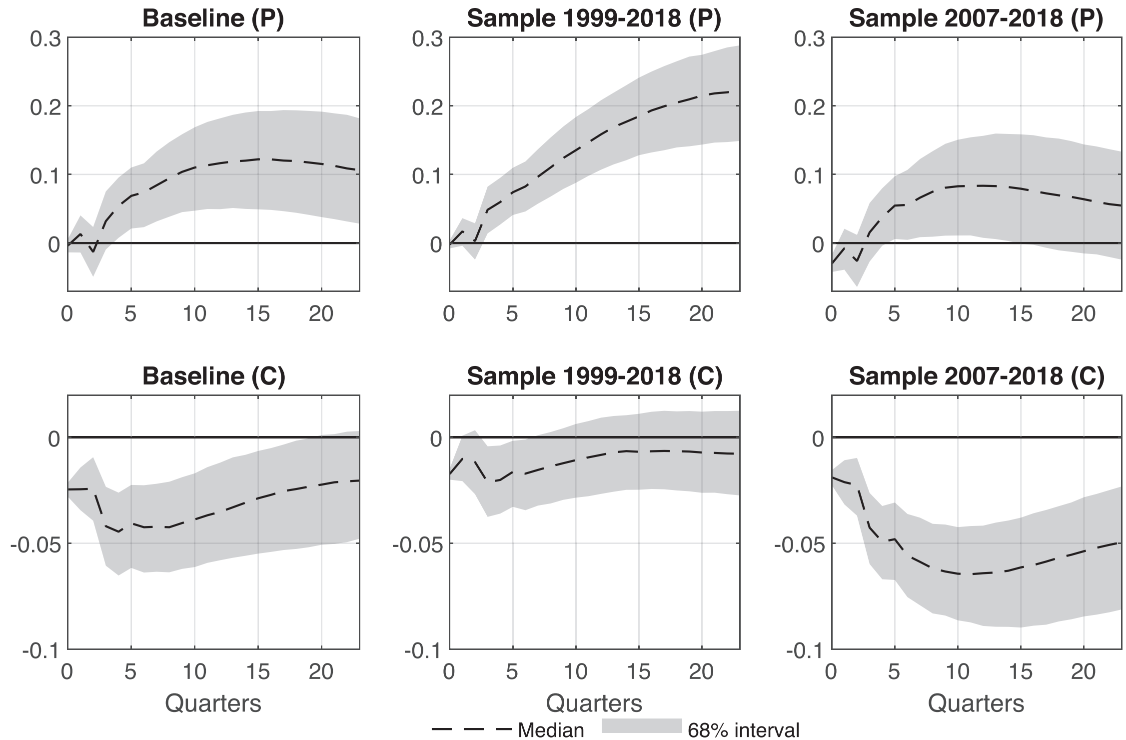


Note: Impulse responses are derived from VAR systems comprising six variables. The figure shows the responses of the variables that are added to the baseline model one-by-one (bottom row), as well as the associated reaction of the domestic government bond share (top row). Median impulse responses are depicted by the dashed lines. The shaded areas represent the 16th and 84th percentiles of the posterior distribution. The response of real house prices and bank equity index are in percent, while the responses of all other variables are in percentage points.

7. Conclusion

Euro-area countries made significant efforts to improve their regulatory framework in the aftermath of the Global Financial Crisis. The aim was to strengthen banks' resilience by imposing regulatory reforms. However, concerns have been raised that capital-based

Figure 11. Alternative Sample Periods: Response of Domestic Government Bond Share



Note: The median impulse responses are depicted by the dashed lines. The shaded areas represent the 16th and 84th percentiles of the posterior distribution. (P) indicates impulse responses for "periphery," (C) for "core." Responses are in percentage points.

macroprudential instruments, that is, those related to bank capital regulation, could have the unintended side effect of intensifying the sovereign-bank nexus, thus potentially undermining financial stability.

Using panel VAR models, we investigate how euro-area banks' incentives to increase their exposure to domestic sovereign debt are affected by shocks to capital-based macroprudential policy measures. We refer to the Macroprudential Policy Evaluation Database to construct a macroprudential policy indicator. Our findings suggest that banks in peripheral countries increase their domestic government bond holdings relative to total assets in response to an unsystematic macroprudential policy tightening. Thus, stricter capital-based macroprudential policy measures seem to strengthen the sovereign-bank nexus. In contrast, banks in core countries decrease their government bond holdings to total assets following a restrictive shock. Estimating state-dependent impulse responses suggests that our results can be explained by the differences in capital positions across the country groups. The findings are robust to various alternative model specifications.

Macroprudential capital regulation is a successful instrument for increasing the loss-absorption capacity of the financial system, thus counteracting the buildup of systemic risk. However, our results suggest that in parts of the EMU, shifts in the unsystematic part of capital-based policy might increase banks' exposure to sovereign debt, which poses a risk to financial stability by strengthening the sovereign-bank nexus.

Appendix A. Data

Bank for International Settlements:

- Credit-to-GDP gap in percent, quarterly frequency, `Q:**:P:A:C`
- Nominal house prices, index: `Q:**:N:628`

ECB Statistical Data Warehouse:

- MFIs' holdings of domestic government bonds, outstanding amount (stock) in millions of euro, monthly frequency,
  `BSI.M.**.N.A.A30.A.1.U6.2100.EUR.E`
  This series was converted to quarterly end-of-period values based on the monthly observations.
- Total assets of a country's MFIs, outstanding amount (stock) in millions of euro, monthly frequency,
  `BSI.M.**.N.A.T00.A.1.Z5.0000.Z01.E`
  This series was converted to quarterly end-of-period values based on the monthly observations.
- MFI loan volume corresponds to the sum of loans to households for house purchase and NFC loans:
  1. MFI volume of loans to households for house purchase, monthly frequency, end-of-period stock,
     `BSI.M.**.N.A.A20.A.1.U6.2250.Z01.E`
  2. MFI volume of loans nonfinancial corporations (NFCs), monthly frequency, end-of-period stock,
     `BSI.M.**.N.A.A20.A.1.U6.2240.Z01.E`

  These series were converted to quarterly end-of-period values based on the monthly observations.
- Lending spreads are computed as the difference between average loan rates and the EURIBOR. The average loan rate corresponds to the weighted average over the lending rates on loans for house purchase and on NFC loans. The weights correspond to the respective share of loans for house purchase and of NFC loans in total loans.
  1. Lending rate on loans to households for house purchase, new business, monthly frequency,
     `MIR.M.**.B.A2C.A.R.A.2250.EUR.N`
  2. Lending rate on loans to NFCs, new business, monthly frequency,
     `MIR.M.**.B.A2A.A.R.A.2240.EUR.N`
  3. Three-month EURIBOR, monthly frequency, average,
     `FM.M.U2.EUR.RT.MM.EURIBOR3MD_.HSTA`

  These series were converted to quarterly averages based on the monthly observations.
- Financial stress indicator, monthly frequency,
  `CLIFS.M.**._Z.4F.EC.CLIFS_CI.IDX`

This series was converted to quarterly averages based on monthly values.

- Banks' capital and reserves (banks' equity), outstanding amount, monthly frequency, end-of-period stocks,
  BSI.M.**.N.A.L60.X.1.Z5.0000.Z01.E
  This series was converted to quarterly end-of-period values based on the monthly observations.
- MFIs' holdings of government bonds issued by other EMU countries, outstanding amount (stock) in millions of euro, monthly frequency,
  BSI.M.**.N.A.A30.A.1.U5.2100.EUR.E
  This series was converted to quarterly end-of-period values based on the monthly observations.
- Sovereign bond rate, monthly frequency,
  IRS.M.**.L.L40.CI.0000.EUR.N.Z
  This is converted to quarterly data using monthly averages.
- Gross domestic product at market prices, deflator, index,
  MNA.Q.Y.**.W2.S1.S1.B.B1GQ._Z._Z._Z.IX.D.N
- National central banks' total assets, outstanding amounts at the end of the period (stocks), millions of euro, monthly frequency,
  BSI.M.**.N.N.T00.A.1.Z5.0000.Z01.E
  This series was converted to quarterly end-of-period values based on the monthly observations.

Refinitiv-Datastream:

- Stock market index, sectoral subindex for "Banks,"
  BANKS**
  This is converted to quarterly data using monthly averages.
- Credit default swaps, five-year government bonds,
  **G5EAC
  This is converted to quarterly data using monthly averages.

Shadow short rate:

- Leo Krippner's shadow short rate is taken from https://www.ljkmfa.com/.

The set of countries comprises Austria (AT), Belgium (BE), Germany (DE), Spain (ES), Finland (FI), France (FR), Ireland (IE), Italy (IT), the Netherlands (NL), and Portugal (PT). In the series' codes ** is a placeholder for the respective country acronym.

Appendix B. Additional Robustness Checks

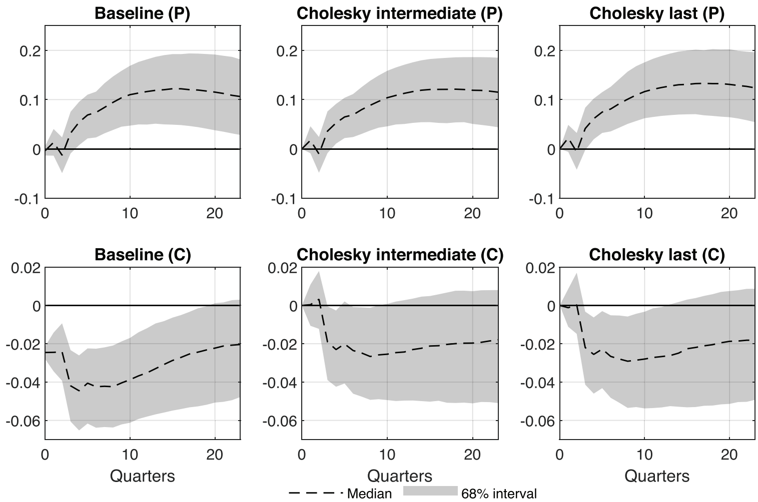
This appendix provides additional robustness checks of our model. Section B.1 provides technical checks for Cholesky orderings, treatment of the MPI, additional controls, and lag length, while Section B.2 shows robustness for macroprudential indicators derived from alternative data sources.

B.1 Further Robustness Checks: Identification, Detrending the MPI, Adding Macroeconomic Controls, and Lag Structure

Identification. The assessment of robustness to alternative Cholesky orderings of the VAR is performed in many studies, such as Bloom (2009), Baker, Bloom, and Davis (2016), and Meinen and Roehe (2017) in the context of uncertainty shocks, or by Kim and Mehrotra (2017, 2018, 2022) or Bachmann and Rueth (2020) in the context of shocks to macroprudential policy. Following these studies, we replace the baseline structural shock identification scheme described in Section 3.3 with two alternative recursive orderings.

The first assumes that MPI is ordered after the credit-to-GDP gap and banks' domestic sovereign bond share but before the CLIFS and the interest spread. Thus, the latter two variables are allowed to respond immediately to a macroprudential policy shock, whereas the former two variables respond with a delay. Hence, MPI is no longer the slowest-moving variable in the model, as it can react immediately to innovations in the equations for the credit-to-GDP gap and domestic government bond holdings ratio. The second alternative ordering assumes that MPI is ordered last. Accordingly, the macroprudential policy shock affects only the indicator itself, while the remaining variables start to react in the following quarter. The two alternative orderings assume a high degree of short-run flexibility to macroprudential policy, as it can react to some or all exogenous shocks within a quarter. However, as discussed in Section 3.3,

Figure B.1. Alternative Cholesky Orderings: Response of Domestic Government Bond Share



Note: Median impulse responses are depicted by the dashed lines. The shaded areas represent the 16th and 84th percentiles of the posterior distribution. (P) indicates impulse responses for "periphery," (C) for "core." Responses are in percentage points.

the empirical evidence and historical experience favors our baseline Cholesky ordering.

Figure B.1 reports the reaction of banks' share of domestic government bonds under the baseline alongside the two alternative Cholesky orderings. As can be seen, variations in the recursive identification scheme leave our main result qualitatively unchanged.

The finding that our results are robust to different Cholesky orderings indicates that the error term in the MPI equation, while controlling for the lags of the endogenous variables in the model, is (close to) orthogonal to the other structural shocks potentially hitting the system (Sims 1981; Lütkepohl 1999). This is reassuring, as it indicates that the residual in the MPI equation in (1) is unlikely to be a linear combination of structural shocks other than the MPI shock itself.

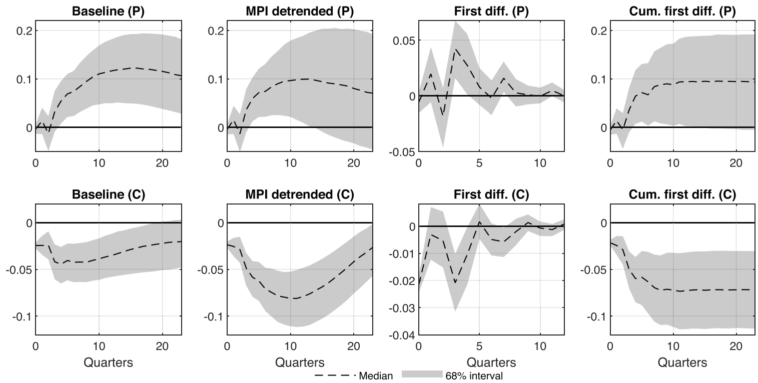
Detrending and Differencing the MPI. The cumulative macroprudential policy indicator $MPI_{k,t}$ is an upward-trending variable. To test whether this drives our results, we implement two additional robustness checks. First, a country-specific linear trend is removed from the cumulative macroprudential policy indicator $MPI_{k,t}$ and the resulting deviation from trend enters the VAR instead of the cumulative $MPI_{k,t}$. Second, we estimate a version of the VAR in which each variable except the lending spread enters as a first difference relative to the previous quarter. Note that such differencing might appear warranted since for the sample under consideration, the model variables—apart from the lending spread—are highly persistent, exhibiting a (close to) unit-root behavior.[28] Note further that the first difference of the $\Delta MPI_{k,t} = MPI_{k,t} - MPI_{k,t-1}$ corresponds to the policy change $PolChange_{k,t}$ in country k and period t.

The reaction of the share of domestic government bonds in banks' portfolios for each of the two robustness checks are shown in Figure B.2. It turns out that our baseline findings are confirmed, i.e., in the periphery economies, there is a significant shift toward higher exposure to domestic government debt while the opposite happens in the core. As expected, when the model variables are in first differences, the impulse responses are much less persistent, being insignificant at horizons larger than 10 quarters (see third column in Figure B.2). Nevertheless, we observe a short-lived but significant increase in banks' domestic-government-bond share in the periphery economies. The corresponding reaction in the core of the EMU has the opposite sign. For the sake of a better comparability, the rightmost column of Figure B.2 shows the *cumulative* impulse responses based on the estimates in first differences shown in the third column of the figure.

Adding Additional Macroeconomic Control Variables. One might suspect that our VAR system, which focuses on variables central to a macroprudential regulator's information set, could yield different results if it includes a broader set of macroeonomic variables. Here we investigate this point. In particular, we run a VAR containing seven endogenous variables, that is, apart from the five variables of our baseline the model also includes the log of real GDP as a measure of real activity and the log of the GDP deflator as a proxy for nominal price developments. More precisely, the seven

[28]The results are qualitatively and quantitatively almost identical if the lending spread is also first-differenced.

Figure B.2. Detrended MPI and Model in First Differences: Response of Banks' Domestic Government Bond Share



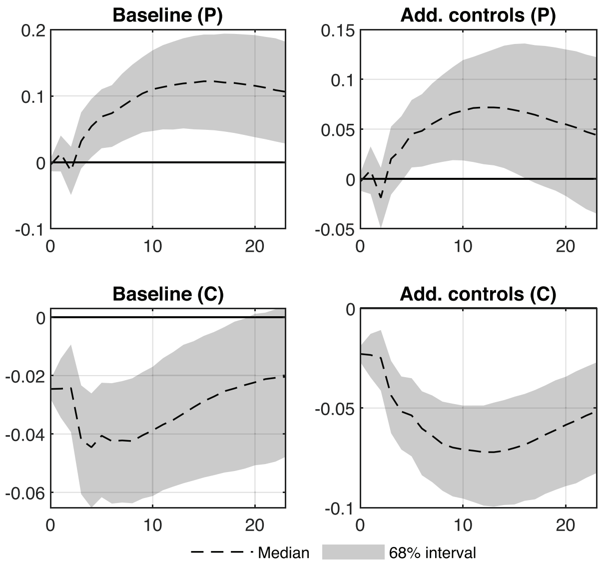
Note: The median impulse responses are depicted by the dashed lines. The shaded areas represent the 16th and 84th percentiles of the posterior distribution. (P) indicates impulse responses for "periphery," (C) for "core." "Baseline" refers to the baseline VAR described in Section 3.1 of the paper. "MPI detrended" refers to the case where the macroprudential policy indicator $MPI_{k,t}$ is linearly detrended, thus entering the VAR as a deviation from its linear trend. "First diff." refers to the model estimated in first differences, that is, each variable except the lending spread is first-differenced. "Cum. first diff." shows the *cumulative* impulse response corresponding to the response shown in column 3, "First diff."

variables are (i) the capital-based MPI, (ii) the credit-to-GDP gap, (iii) the lending spread, (iv) the financial stress indicator, (v) the domestic government bond share in banks' portfolios, (vi) the log of real GDP, and (vii) the log of the GDP deflator. The MPI is again ordered first and the lag order is again set to four.

The impulse responses of banks' domestic government bond share to an unsystematic macroprudential tightening for the two country groups are shown in Figure B.3. As can be seen, our baseline results are robust in this alternative specification: in the peripheral countries, banks react by significantly increasing the fraction of domestic sovereign bonds in their portfolios. By contrast, in the core countries the opposite holds true.

Lags. Moreover, our results are qualitatively unchanged if the panel VAR model is estimated with between two and six lags instead

Figure B.3. Seven-Variable VAR (including the log of GDP and the log of the GDP deflator): Response of Banks' Domestic Government Bond Share



Note: Median impulse responses for the respective models are depicted by the dashed lines. The shaded areas represent the 16th and 84th percentiles of the posterior distribution. (P) indicates impulse responses for "periphery," (C) for "core." "Baseline" refers to the baseline VAR described in Section 3.1 of the paper. "Add. controls" refers to the case where two additional endogenous variables, the log of real GDP and the log of the GDP deflator, are included in the VAR.

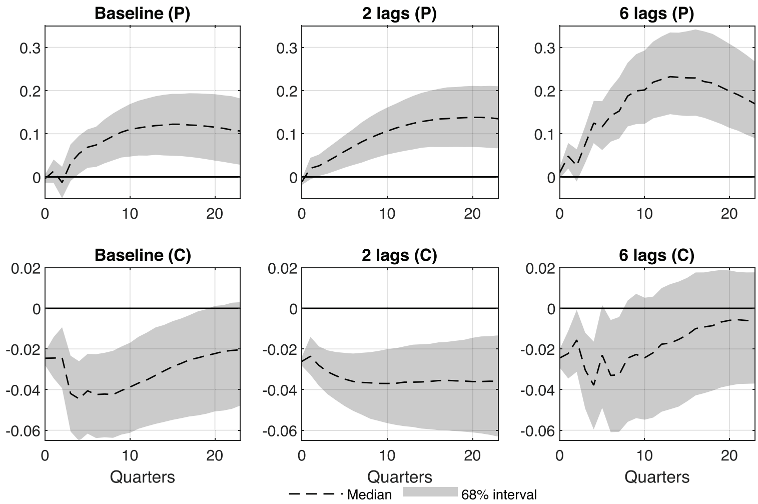
of four. In Figure B.4, the second and third columns summarize the results.[29]

B.2 Alternative Macroprudential Policy Indicators Adjusted for Basel III and from the IMF

Next, we assess the robustness of our findings with regard to the macroprudential policy indicator. First, we construct two alternative policy indicators based on MaPPED in which we adjust for

[29] Impulse responses for the case of three and five lags are very similar to the ones shown.

Figure B.4. Alternative Lag Structures: Response of Domestic Government Bond Share



Note: The median impulse responses are depicted by the dashed lines. The shaded areas represent the 16th and 84th percentiles of the posterior distribution. (P) indicates impulse responses for "periphery," (C) for "core." Responses are in percentage points.

cross-country inconsistencies regarding the reporting of measures related to Basel III. Second, we construct an analogous capital-based indicator based on iMaPP.

MPI Adjusted for Basel III Measures. The third installment of the Basel Accords, better known as Basel III, was agreed upon by the members of the Basel Committee on Banking Supervision in November 2010. The accord was developed in response to the regulatory deficiencies revealed by the Global Financial Crisis of 2007–08 and aimed at strengthening the resilience of the banking system by tightening capital requirements and increasing bank liquidity. Countries committed to adopting Basel III were expected to translate the accord into national law within a certain period of time.[30] In the EU, countries had to impose new regulatory requirements

[30]See BCBS (2011, 2012) and https://www.bis.org/bcbs/basel3/b3_trans_arr_1728.pdf.

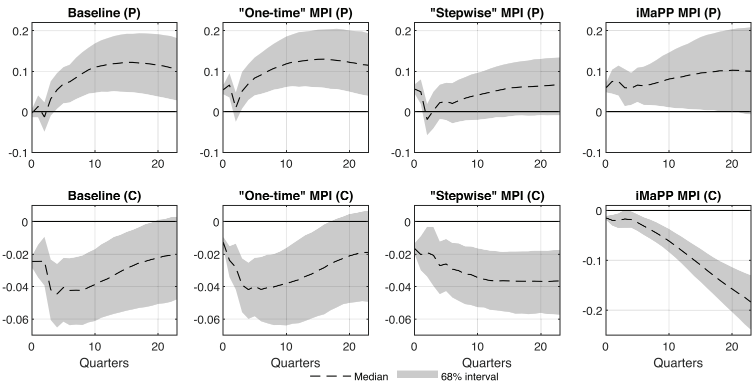
by gradually tightening them during a prespecified phase-in period until the final level was reached. Countries were allowed to shorten the phase-in period or impose more stringent final regulations, but not the opposite.

However, although Basel III regulations apply equally to all EU member states, their appearance in MaPPED is rather heterogeneous and inconsistent across countries. In particular, there is considerable variation in the way national authorities have reported the activation and subsequent adjustments of the (i) minimum common equity tier 1 capital ratio (CET1), (ii) minimum tier 1 capital ratio, (iii) capital conservation buffer (CCoB), and additional capital requirements for (iv) global systemically important institutions (G-SIIs) as well as for (v) other systemically important institutions (O-SIIs).[31] For example, several national authorities do not report some of these measures, while others only report a single macroprudential tightening on the date when the corresponding measure reached its final level and was thus fully phased in. Finally, a set of countries explicitly report each of the stepwise tightening measures along with the phase-in path for some of the aforementioned Basel III measures.

To cope with this heterogeneity, we construct two adjusted macroprudential policy indicators. In the first, termed $MPI^{stepwise}$, we assume that each tightening step along the envisaged phase-in of the corresponding measure should be reflected by an entry of +1 in the discretely coded indicator. National MPIs are adjusted accordingly in the case where a country reports the particular Basel III measure differently, i.e., did not report it at all or reported it only as a single tightening. The cases in which a country officially announced and implemented a faster phase-in for a particular measure are accounted for. The changes were verified based on macroprudential notifications collected and published by the

[31] The Basel III Accord prescribes the following regulatory adjustments: the minimum common equity tier 1 capital ratio (CET1) to be set to 3.5 percent in 2013:Q2 and raised to 4.5 percent in 2015:Q1, the minimum tier 1 capital ratio to be set to 4.5 percent in 2013:Q2 and raised to 6.0 percent in 2015:Q1, the capital conservation buffer (CCoB) to be set at 0.625 percent in 2016:Q1 and raised to 2.5 percent in 2019:Q1, and the G-SII and O-SII buffers to be activated in 2016:Q1 and increased until 2019:Q1 by a constant bucket-specific increment each year.

Figure B.5. Alternative Macroprudential Indicators (Basel III and iMaPP): Response of Domestic Government Bond Share



Note: Median impulse responses for the respective models are depicted by the dashed lines. The shaded areas represent the 16th and 84th percentiles of the posterior distribution. (P) indicates impulse responses for "periphery," (C) for "core." "One-time MPI" and "Stepwise MPI" represent capital-based policy indicators with adjustments for the phase-in of Basel III measures. "iMaPP MPI" is a capital-based policy indicator derived from iMaPP. Responses are in percentage points. Note that the y-axis for "iMaPP" differs in scaling from the other y-axes in the bottom row.

ESRB.[32] In the second, termed $MPI^{\text{one-time}}$, we replace each of the aforementioned phased-in measures with a single tightening in the quarter in which the first step of the corresponding measure was activated (for details on the precise adjustments for MPI^{stepwise} and $MPI^{\text{one-time}}$, see Appendix C).

Figure B.5 summarizes the impulse responses of banks' domestic government bond holdings ratio to an innovation in each of the two alternative indicators. Overall, the reaction to both alternative shocks is quite similar to our baseline. However, regarding the timing of the response of the government bond holdings ratio to the alternative shocks, it appears that the increase in the ratio occurs more swiftly, that is, the ratio begins to rise with the impact of both shocks. The quantitative effects on peripheral banks' sovereign

[32]See https://www.esrb.europa.eu/national_policy/shared/pdf/esrb.measures_overview_macroprudential_measures.xlsx?b4d0d267f4fe73eaeca1caa84e946109.

exposures are also larger for the one-time indicator, i.e., we observe a maximum increase of 14 percent instead of 11 percent of the share.

MPI Based on iMaPP. Finally, we construct a dummy-type capital-based MPI based on iMaPP covering the categories *Countercyclical buffers (C1.CCB)*, *Conservation buffers (C2.Conservation)*, *Minimum requirements and risk weights (C3.Capital)*, *Leverage requirements (C4.LVR),* and *Loan-loss provisioning (C5.LLP).* In contrast to MaPPED, iMaPP has a more limited coverage of capital-based measures in the EMU for the period before 2011. In addition, in some cases there are differences in how the two databases characterize measures. For example, sometimes a policy action is described as "with ambiguous impact" in one database while being characterized as a "tightening" in the other. Since a harmonization of iMaPP and MaPPED is beyond the scope of our analysis, we take such differences as given. Figure B.5 shows the reaction of the banks' government bond holdings ratio to a shock to the capital-based iMaPP indicator. The impulse responses deliver a qualitatively similar pattern as reported before.[33] While for core countries the response of the domestic government bond share is slower but more persistent, it is both qualitatively and quantitatively similar for the periphery.

Appendix C. Alternative Macroprudential Policy Indicators

We construct two alternative manually adjusted macroprudential policy indices based on MaPPED as follows:

$\text{MPI}^{\text{stepwise}}$:

- Minimum Common Equity Tier 1 Capital Ratio (CET1): insert a tightening in 2013:Q2 for AT, DE, ES, FI, FR, IE,

[33]Note that in a series of additional exercises, we found that our results also hold when estimating the VAR with the iMaPP-based MPI over the periods 1999 to 2018 and 2007 to 2018. The results are not reported here, but are available upon request.

IT, NL, PT; insert a tightening in 2014:Q1 for AT, DE, ES, PT.[34]
- Minimum Tier 1 Capital Ratio: insert a tightening in 2013:Q2 for AT, DE, ES, FI, FR, IE, IT, NL, PT; insert a tightening in 2014:Q1 for AT, DE, ES.[35]
- Capital Conservation Buffer (CCoB): insert tightening in 2016:Q1, 2017:Q1, 2018:Q1, and 2019:Q1 for AT, BE, DE, FR, ES, IE, NL, PT.[36]
- G-SII Buffer: insert tightening in 2016:Q1, 2017:Q1, 2018:Q1, 2019:Q1 for AT, BE, DE, FI, FR, ES, IE, and NL.
- O-SII Buffer: insert tightening in 2016:Q1, 2017:Q1, 2018:Q1, 2019:Q1 for AT, BE, DE, FR, ES, IE, IT, PT; insert tightening in 2017:Q1, 2018:Q1, and 2019:Q1 for FI.

$MPI^{\text{one-time}}$:

- Minimum Common Equity Tier 1 Capital Ratio (CET1): remove tightening in 2015:Q1 for AT, BE, DE, ES, FR, IE; remove tightening in 2014:Q1 for BE, FR, IE; insert tightening in 2013:Q2 for AT, DE, ES, FR, IE.
- Minimum Tier 1 Capital Ratio: remove tightening in 2015:Q1 for AT, BE, DE, ES, FR, IE; remove tightening in 2014:Q1 for BE; insert tightening in 2013:Q2 for AT, DE, ES.
- Capital Conservation Buffer (CCoB): insert a tightening in 2016:Q1 for AT, BE, DE, ES, FR, IE, NL, PT.
- G-SII Buffer: remove tightening in 2017:Q1, 2018:Q1, and 2019:Q1 for IT; insert a tightening in 2016:Q1 for AT, BE, DE, FI, FR, ES, and NL.
- O-SII Buffer: FI is left unchanged; remove tightening in 2017:Q1, 2018:Q1, 2019:Q1 for NL; insert a tightening in 2016:Q1 for AT, BE, DE, FR, ES, IE, IT, PT.

[34] In FI, IT, and NL the CET1 was phased in at a faster pace and was fully implemented in 2014:Q1.

[35] In FI, IT, NL, and PT, the minimum tier 1 capital ratio was phased in at a faster pace and was fully implemented in 2014:Q1.

[36] In IT the CCoB was fully implemented via a single tightening step in 2014:Q1.

References

Acharya, V., K. Bergant, M. Crosignani, T. Eisert, and F. McCann. 2022. “The Anatomy of the Transmission of Macroprudential Policies.” *Journal of Finance* 77 (5): 2533–75.

Acharya, V., I. Drechsler, and P. Schnabl. 2014. “A Pyrrhic Victory? Bank Bailouts and Sovereign Credit Risk.” *Journal of Finance* 69 (6): 2689–739.

Acharya, V., R. Engle, and D. Pierret. 2014. “Testing Macroprudential Stress Tests: The Risk of Regulatory Risk Weights.” *Journal of Monetary Economics* 65 (July): 36–53.

Acharya, V. V., and S. Steffen. 2015. “The ‘Greatest’ Carry Trade Ever? Understanding Eurozone Bank Risks.” *Journal of Financial Economics* 115 (2): 215–36.

Adrian, T., F. Grinberg, N. Liang, S. Malik, and J. Yu. 2022. “The Term Structure of Growth-at-Risk.” *American Economic Journal: Macroeconomics* 14 (3): 283–323.

Akinci, O., and J. Olmstead-Rumsey. 2018. “How Effective are Macroprudential Policies? An Empirical Investigation.” *Journal of Financial Intermediation* 33 (January): 33–57.

Alam, Z., A. Alter, J. Eiseman, R. Gelos, H. Kang, M. Narita, E. Nier, and N. Wang. 2019. “Digging Deeper—Evidence on the Effects of Macroprudential Policies from a New Database.” IMF Working Paper No. 19/66.

Altavilla, C., M. Darracq Pariès, and G. Nicoletti. 2019. “Loan Supply, Credit Markets and the Euro Area Financial Crisis.” *Journal of Banking and Finance* 109 (December): Article 105658.

Altavilla, C., M. Pagano, and S. Simonelli. 2017. “Bank Exposures and Sovereign Stress Transmission.” *Review of Finance* 21 (6): 2103–39.

Altunbas, Y., M. Binici, and L. Gambacorta. 2018. “Macroprudential Policy and Bank Risk.” *Journal of International Money and Finance* 81 (March): 203–20.

Angelini, P., S. Neri, and F. Panetta. 2014. “The Interaction between Capital Requirements and Monetary Policy.” *Journal of Money, Credit and Banking* 46 (6): 1073–112.

Arslan, Y., and C. Upper. 2017. “Macroprudential Frameworks: Implementation and Effectiveness.” *BIS Papers* 94: 25–47.

Bachmann, R., and S. K. Rueth. 2020. "Systematic Monetary Policy and the Macroeconomic Effects of Shifts in Residential Loan-to-Value Ratios." *International Economic Review* 61 (2): 503–30.

Baker, S. R., N. Bloom, and S. J. Davis. 2016. "Measuring Economic Policy Uncertainty." *Quarterly Journal of Economics* 131 (4): 1593–636.

Bakker, B. B., G. Dell'Ariccia, L. Laeven, J. Vandenbussche, D. O. Igan, and H. Tong. 2012. "Policies for Macrofinancial Stability: How to Deal with Credit Booms." IMF Staff Discussion Note No. 12/06.

Basel Committee on Banking Supervision. 2010. "Guidance for National Authorities Operating the Countercyclical Capital Buffer." Bank for International Settlements, December.

———. 2011. "Basel III: A Global Regulatory Framework for More Resilient Banks and Banking Systems." Bank for International Settlements, June.

———. 2012. "A Framework for Dealing with Domestic Systemically Important Banks." Bank for International Settlements, October.

———. 2017. "The Regulatory Treatment of Sovereign Exposures." Discussion Paper, Bank for International Settlements, December.

Battistini, N., M. Pagano, and S. Simonelli. 2014. "Systemic Risk, Sovereign Yields and Bank Exposures in the Euro Crisis." *Economic Policy* 29 (78): 203–51.

Becker, B., and V. Ivashina. 2018. "Financial Repression in the European Sovereign Debt Crisis." *Review of Finance* 22 (1): 83–115.

Behn, M., M. Gross, and T. A. Peltonen. 2016. "Assessing the Costs and Benefits of Capital-based Macroprudential Policy." ECB Working Paper No. 1935.

Benes, J., and M. Kumhof. 2015. "Risky Bank Lending and Countercyclical Capital Buffers." *Journal of Economic Dynamics and Control* 58 (September): 58–80.

Berrospide, J. M., and R. M. Edge. 2010. "The Effects of Bank Capital on Lending: What Do We Know, and What Does It Mean?" *International Journal of Central Banking* 6 (4): 1–50.

Bilbiie, F. O., T. Monacelli, and R. Perotti. 2021. "Fiscal Policy in Europe: A Helicopter View." *Journal of Economic Perspectives* 35 (2): 77–100.

Bloom, N. 2009. "The Impact of Uncertainty Shocks." *Econometrica* 77 (3): 623–85.

Boar, C., L. Gambacorta, G. Lombardo, and L. A. P. da Silva. 2017. "What Are the Effects of Macroprudential Policies on Macroeconomic Performance?" *BIS Quarterly Review* (September): 71–88.

Boeckx, J., M. Dossche, and G. Peersman. 2017. "Effectiveness and Transmission of the ECB's Balance Sheet Policies." *International Journal of Central Banking* 13 (1): 297–333.

Bonner, C. 2016. "Preferential Regulatory Treatment and Banks' Demand for Government Bonds." *Journal of Money, Credit and Banking* 48 (6): 1195–221.

Bridges, J., D. Gregory, M. Nielsen, S. Pezzini, A. Radia, and M. Spaltro. 2014. "The Impact of Capital Requirements on Bank Lending." Working Paper No. 486, Bank of England.

Brunnermeier, M. K., L. Garicano, P. R. Lane, M. Pagano, R. Reis, T. Santos, D. Thesmar, S. V. Nieuwerburgh, and D. Vayanos. 2016. "The Sovereign-Bank Diabolic Loop and ESBies." *American Economic Review* 106 (5): 508–12.

Bruno, V., I. Shim, and H. S. Shin. 2017. "Comparative Assessment of Macroprudential Policies." *Journal of Financial Stability* 28 (February): 183–202.

Budnik, K. 2020. "The Effect of Macroprudential Policies on Credit Developments in Europe 1995-2017." ECB Working Paper No. 2462.

Budnik, K., and J. Kleibl. 2018. "Macroprudential Regulation in the European Union in 1995-2014: Introducing a New Data Set on Policy Actions of a Macroprudential Nature." ECB Working Paper No. 2123.

Budnik, K., and G. Rünstler. 2023. "Identifying Structural VARs from Sparse Narrative Instruments: Dynamic Effects of US Macroprudential Policies." *Journal of Applied Econometrics* 38 (2): 186–201.

Buera, F. J., J. P. Kaboski, and R. M. Townsend. 2023. "From Micro to Macro Development." *Journal of Economic Literature* 61 (2): 471–503.

Buser, S. A., A. H. Chen, and E. J. Kane. 1981. "Federal Deposit Insurance, Regulatory Policy, and Optimal Bank Capital." *Journal of Finance* 36 (1): 51–60.

Calem, P., and R. Rob. 1999. "The Impact of Capital-based Regulation on Bank Risk-taking." *Journal of Financial Intermediation* 8 (4): 317–52.

Calomiris, C. W., and C. M. Kahn. 1991. "The Role of Demandable Debt in Structuring Optimal Banking Arrangements." *American Economic Review* 81 (3): 497–513.

Carpinelli, L., and M. Crosignani. 2021. "The Design and Transmission of Central Bank Liquidity Provisions. *Journal of Financial Economics* 141 (1): 27–47.

Cerutti, E., S. Claessens, and L. Laeven. 2017. "The Use and Effectiveness of Macroprudential Policies: New Evidence." *Journal of Financial Stability* 28 (February): 203–24.

Cerutti, E., R. Correa, E. Fiorentino, and E. Segalla. 2017. "Changes in Prudential Policy Instruments — A New Cross-Country Database." *International Journal of Central Banking* 13 (Supplement 1): 477–503.

Ciccarelli, M., A. Maddaloni, and J. L. Peydró. 2015. "Trusting the Bankers: A New Look at the Credit Channel of Monetary Policy." *Review of Economic Dynamics* 18 (4): 979–1002.

Cizel, J., J. Frost, A. Houben, and P. Wierts. 2019. "Effective Macroprudential Policy: Cross-Sector Substitution from Price and Quantity Measures." *Journal of Money, Credit and Banking* 51 (5): 1209–35.

Claessens, S. 2015. "An Overview of Macroprudential Policy Tools." *Annual Review of Financial Economics* 7: 397–422.

Claessens, S., S. R. Ghosh, and R. Mihet. 2013. "Macro-prudential Policies to Mitigate Financial System Vulnerabilities." *Journal of International Money and Finance* 39 (December): 153–85.

Crosignani, M., M. Faria-e Castro, and L. Fonseca. 2020. "The (unintended?) Consequences of the Largest Liquidity Injection Ever." *Journal of Monetary Economics* 112 (June): 97–112.

Crowe, C., G. Dell'Ariccia, D. Igan, and P. Rabanal. 2013. "How to Deal with Real Estate Booms: Lessons from Country Experiences." *Journal of Financial Stability* 9 (3): 300–319.

Dagher, J. 2018. "Regulatory Cycles: Revisiting the Political Economy of Financial Crises." IMF Working Paper No. 18/8.

Dell'Ariccia, G., C. Ferreira, N. Jenkinson, L. Laeven, A. Martin, C. Minoiu, and A. Popov. 2018. "Managing the Sovereign-Bank Nexus." ECB Working Paper No. 2177.

Drechsler, I., T. Drechsel, D. Marques-Ibanez, and P. Schnabl. 2016. "Who Borrows from the Lender of Last Resort?" *Journal of Finance* 71 (5): 1933–74.

Drehmann, M., C. Borio, and K. Tsatsaronis. 2011. "Anchoring Countercyclical Capital Buffers: The Role of Credit Aggregates." *International Journal of Central Banking* 7 (4): 189–240.

Drehmann, M., and M. Juselius. 2014. "Evaluating Early Warning Indicators of Banking Crises: Satisfying Policy Requirements." *International Journal of Forecasting* 30 (3): 759–80.

Driscoll, J. C., and A. C. Kraay. 1998. "Consistent Covariance Matrix Estimation with Spatially Dependent Panel Data." *Review of Economics and Statistics* 80 (4): 549–60.

Edge, R. M., and J. N. Liang. 2020. "Financial Stability Committees and the Countercyclical Capital Buffer." Discussion Paper No. 04/2020, Deutsche Bundesbank.

———. 2022. "Financial Stability Committees and the Basel III Countercyclical Capital Buffer." *International Journal of Central Banking* 18 (5): 247–99.

Eickmeier, S., B. Kolb, and E. Prieto. 2018. "Macroeconomic Effects of Bank Capital Regulation." Discussion Paper No. 44/2018, Deutsche Bundesbank.

European Central Bank. 2020. "Financial Stability Review, November 2020."

———. 2022. "Financial Stability Review, November 2022."

European Systemic Risk Board. 2019a. "A Review of Macroprudential Policy in the EU in 2018."

———. 2019b. "Report on the Regulatory Treatment of Sovereign Exposures, March 2019."

———. 2021. "A Review of Macroprudential Policy in the EU in 2020."

———. 2022. "Annual Report 2021."

Farhi, E., and J. Tirole. 2018. "Deadly Embrace: Sovereign and Financial Balance Sheets Doom Loops." *Review of Economic Studies* 85 (3): 1781–823.

Galati, G., and R. Moessner. 2018. "What Do We Know About the Effects of Macroprudential Policy?" *Economica* 85 (340): 735–70.

Gambacorta, L., B. Hofmann, and G. Peersman. 2014. "The Effectiveness of Unconventional Monetary Policy at the Zero Lower Bound: A Cross-country Analysis." *Journal of Money, Credit and Banking* 46 (4): 615–42.

Gambacorta, L., and A. Murcia. 2019. "The Impact of Macroprudential Policies and Their Interaction with Monetary Policy: An

Empirical Analysis Using Credit Registry Data." In *Are Post-crisis Statistical Initiatives Completed?* IFC Bulletin No. 49, Bank for International Settlements.

Gonzalez, F. 2005. "Bank Regulation and Risk-taking Incentives: An International Comparison of Bank Risk." *Journal of Banking and Finance* 29 (5): 1153–84.

Gourinchas, P. O., and M. Obstfeld. 2012. "Stories of the Twentieth Century for the Twenty-First." *American Economic Journal: Macroeconomics* 4 (1): 226–65.

Gropp, R., T. Mosk, S. Ongena, and C. Wix. 2019. "Banks Response to Higher Capital Requirements: Evidence from a Quasi-Natural Experiment." *Review of Financial Studies* 32 (1): 266–99.

Gross, M., C. Kok, and D. Zochowski. 2016. "The Impact of Bank Capital on Economic Activity — Evidence from a Mixed-Cross-Section GVAR Model." ECB Working Paper No. 1888.

Hamilton, J. D., and D. Leff. 2020. "Measuring the Credit Gap." Mimeo.

Heid, F., D. Porath, and S. Stolz. 2004. "Does Capital Regulation Matter for Bank Behaviour? Evidence for German Savings Banks." Discussion Paper No. 03/2004, Deutsche Bundesbank.

Hristov, N., O. Hülsewig, and J. Scharler. 2021. "Unconventional Monetary Policy Shocks in the Euro Area and the Sovereign-Bank Nexus." *International Journal of Central Banking* 17 (3): 337–83.

International Monetary Fund. 2014. "Risk Taking, Liquidity, and Shadow Banking: Cursing Excess While Promoting Growth." Global Financial Stability Report, October.

———. 2018. "A Decade after the Global Financial Crisis: Are We Safer?" Global Financial Stability Report, October.

———. 2019. "Vulnerabilities in a Maturing Credit Cycle." Global Financial Stability Report, April.

Jiménez, G., S. Ongena, J. L. Peydró, and J. Saurina. 2017. "Macroprudential Policy, Countercyclical Bank Capital Buffers, and Credit Supply: Evidence from the Spanish Dynamic Provisioning Experiments." *Journal of Political Economy* 125 (6): 2126–77.

Jokipii, T., and A. Milne. 2011. "Bank Capital Buffer and Risk Adjustment Decisions." *Journal of Financial Stability* 7 (3): 165–78.

Jordà, Ò. 2005. "Estimation and Inference of Impulse Responses by Local Projections." *American Economic Review* 95 (1): 161–82.

Jordà, Ò., M. Schularick, and A. M. Taylor. 2013. "When Credit Bites Back." *Journal of Money, Credit and Banking* 45 (s2): 3–28.

Kanngiesser, D., R. Martin, L. Maurin, and D. Moccero. 2020. "The Macroeconomic Impact of Shocks to Bank Capital Buffers in the Euro Area." *B.E. Journal of Macroeconomics* 20 (1): 1–17.

Kim, S., and A. Mehrotra. 2017. "Managing Price and Financial Stability Objectives in Inflation Targeting Economies in Asia and the Pacific." *Journal of Financial Stability* 29 (April): 106–16.

———. 2018. "Effects of Monetary and Macroprudential Policies — Evidence from Four Inflation Targeting Economies." *Journal of Money, Credit and Banking* 50 (5): 967–92.

———. 2022. "Examining Macroprudential Policy and Its Macroeconomic Effects — Some New Evidence." *Journal of International Money and Finance* 128 (November): Article 102697.

Knot, K. 2014. "Governance of Macroprudential Policy." *Financial Stability Review* 18: 25–32.

Krippner, L. 2013. "Measuring the Stance of Monetary Policy in Zero Lower Bound Environments." *Economics Letters* 118 (1): 135–38.

Krishnamurthy, A., and T. Muir. 2017. "How Credit Cycles across a Financial Crisis." NBER Working Paper No. 23850.

Kuttner, K. N., and I. Shim. 2016. "Can Non-interest Rate Policies Stabilize Housing Markets? Evidence from a Panel of 57 Economies." *Journal of Financial Stability* 26 (October): 31–44.

Leeper, E. M., T. B. Walker, and S. C. S. Yang. 2013. "Fiscal Foresight and Information Flows." *Econometrica* 81 (3): 1115–45.

Lim, C., F. Columba, A. Costa, P. Kongsamut, A. Otani, M. Saiyid, T. Wezel, and X. Wu. 2011. "Macroprudential Policy: What Instruments and How to Use them? Lessons from Country Experiences." IMF Working Paper No. 11/238.

López-Salido, D., J. C. Stein, and E. Zakrajšek. 2017. "Credit-Market Sentiment and the Business Cycle." *Quarterly Journal of Economics* 132 (3): 1373–426.

Lütkepohl, H. 1999. "Vector Autoregressive Analysis." SFB 373 Discussion Paper No. 1999,31. Humboldt University of Berlin, Interdisciplinary Research Project 373: Quantification and Simulation of Economic Processes.

Maddaloni, A., and J. L. Peydró. 2013. "Monetary Policy, Macroprudential Policy, and Banking Stability: Evidence from the Euro Area." *International Journal of Central Banking* 9 (1): 121–69.

Marcus, A. J. 1984. "Deregulation and Bank Financial Policy." *Journal of Banking and Finance* 8 (4): 557–65.

Meeks, R. 2017. "Capital Regulation and the Macroeconomy: Empirical Evidence and Macroprudential Policy." *European Economic Review* 95 (June): 125–41.

Meinen, P., and O. Roehe. 2017. "On Measuring Uncertainty and Its Impact on Investment: Cross-country Evidence from the Euro Area." *European Economic Review* 92 (February): 161–79.

Meuleman, E., and R. Vander Vennet. 2020. "Macroprudential Policy and Bank Systemic Risk." *Journal of Financial Stability* 47 (April): Article 100724.

Noss, J., and P. Toffano. 2016. "Estimating the Impact of Changes in Aggregate Bank Capital Requirements on Lending and Growth during an Upswing." *Journal of Banking and Finance* 62 (January): 15–27.

Ongena, S., A. Popov, and N. van Horen. 2019. "The Invisible Hand of the Government: Moral Suasion during the European Sovereign Debt Crisis." *American Economic Journal: Macroeconomics* 11 (4): 346–79.

Peydró, J. L., A. Polo, and E. Sette. 2021. "Monetary Policy at Work: Security and Credit Application Registers Evidence." *Journal of Financial Economics* 140 (3): 789–814.

Poghosyan, T. 2020. "How Effective is Macroprudential Policy? Evidence from Lending Restriction Measures in EU Countries." *Journal of Housing Economics* 49 (September): Article 101694.

Richter, B., M. Schularick, and I. Shim. 2019. "The Costs of Macroprudential Policy." *Journal of International Economics* 118 (May): 263–82.

Rime, B. 2001. "Capital Requirements and Bank Behaviour: Empirical Evidence for Switzerland." *Journal of Banking and Finance* 25 (4): 789–805.

Shrieves, R. E., and D. Dahl. 1992. "The Relationship between Risk and Capital in Commercial Banks." *Journal of Banking and Finance* 16 (2): 439–57.

Sims, C. A. 1981. "An Autoregressive Index Model for the U.S., 1948-1975." In *Large-Scale Macro-Econometric Models: Theory and Practice,* ed. J. Kmenta and J. B. Ramsey. Amsterdam: North-Holland.

Sims, E. 2012. "News, Non-Invertibility, and Structural VARs." *Advances in Econometrics* 28: 81–135.

Vandenbussche, J., U. Vogel, and E. Detragiache. 2015. "Macroprudential Policies and Housing Prices: A New Database and Empirical Evidence for Central, Eastern, and Southeastern Europe." *Journal of Money, Credit and Banking* 47 (S1): 343–77.

VanHoose, D. 2007. "Theories of Bank Behavior under Capital Regulation." *Journal of Banking and Finance* 31 (12): 3680–97.

———. 2008. "Bank Capital Regulation, Economic Stability, and Monetary Policy: What Does the Academic Literature Tell Us?" *Atlantic Economic Journal* 36: 1–14.

Wolf, C. K. 2023. "The Missing Intercept: A Demand Equivalence Approach." *American Economic Review* 113 (8): 2232–69.